China Report

AGRICULTURE

No. 75

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I. GENERAL INFORMATION

WATER FOR WINTER WHEAT IN NORTH CHINA

Beijing ZHONGGUO NONGYE KEXUE [SCIENTIA AGRICULTURA SINICA] in Chinese
No 4, 1979 pp 16-26

[Article by He Duofen [6320 1122 5358] of the Institute of Agricultural
Natural Resources and Agricultural Zoning of the Chinese Academy of Agri-
cultural Sciences: "Natural Water Conditions of the Growth Period of Winter
Wheat and Their Effect On Yield in Our Nation's Five Northern Provinces*"]

[Text] To reasonably arrange the distribution of agricultural crops and the
areas of planting, it is necessary first to compare the fundamental condi-
tions provided by nature in large areas so that these conditions may be more
fully utilized and the limitations on the possibilities provided by these
conditions are not surpassed. This article discusses some preliminary
studies on the method of calculation of the amount of water supply and the
amount of water needed by winter wheat as determined mainly by meteorological
and soil conditions. And based on this foundation, meteorological data of
many years, and soil properties of various localities, we have drawn up dis-
tribution maps showing the distribution of natural water for winter wheat in
our nation's five northern provinces.

I.

Rainfall in our nation's northern regions over the four seasons is very
unevenly distributed. Over 60 percent of the annual amount of rainfall are
concentrated in the three summer months of June, July and August. There is
little rainfall in winter and spring. The air is dry, its rainy and dry
seasons are clearly separate. Winter wheat is sown immediately after the
rainy season in autumn and is harvested before the rainy season the following
year. It grows just within the year's dry season. Therefore, its growth
and yield are closely related to the amount of water. As the number one
flour (and rice) crop in our nation's northern regions, we must clearly

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* The first draft of this article was completed before the Great Cultural
Revolution. At the time, those participating in the work also included
Comrade Zhao Jubao [6392 5112 1405]. The article was revised to a rather
large extent prior to publication. The five northern provinces are Henan,
Hebei, Shandong, Shanxi and Shaanxi.

understand how water at various localities is assured naturally. The following is a discussion of several aspects of the problem concerning water for winter wheat. Our way of thinking and our considerations and the methods of calculation we have used are separately described. They are: (1) the need for water by winter wheat; (2) the natural supply of water during the growth period (temporarily excluding consideration of underground water); and (3) comparison between the need and the supply.

1. The Need for Water by Winter Wheat

Although many experiments on the need for water by winter wheat have been conducted at various localities, the duration over the years of the experiments has been short and the conditions have not been uniform. It is difficult to show regional changes and annual changes in the amount of water needed based on these experiments.

The major factors affecting the amount of water needed by crops are agriculture and meteorology. Agriculture includes the conditions of the crops themselves, such as variety, condition of growth and measures of planting and cultivation. Where soil moisture does not constitute a limiting factor, these conditions are most likely related to the evapotranspiration characteristic determined by the leaf area index and the characteristics of the variety. Generally speaking, if the above conditions do not change, it can be said that the amount of water needed is dictated only by meteorological conditions.

Meteorological conditions include temperature, sunshine and wind speed which are reflected in the strength of evapotranspiration. Observations and measurements of evaporation conducted by meteorological stations show large differences from the actual amount of evaporation from water surfaces because of the measuring instruments used, and these measurements cannot be used for quantitative calculations. Therefore we tested the Penman formula for calculating evaporative strength. The advantage of this method is that it can be used for ordinary data observed and measured by the thermometer screen common in meteorological stations, and observation and measurement of specific items are not necessary. At the same time, this method itself has a rather strict basis and it has been proven to yield better results in some regions of the world. It has also been tested and proven by people in our nation, and it is believed that the results coincide better with actual evaporation from water surfaces. Its computational formulas are as follows:

$$E_0 = \frac{H\Delta + rE_a}{\Delta + r} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (1)$$

where E_o-------strength of evaporation of water surface (millimeter).

Δ -------slope at t_a on the curve of the variations of tension of water vapors due to temperature changes.

r--------constant of the dry and wet spherical formula equals 0.5.

E_a is the parameter of what Penman calls the drying power derived from the following formula:

$$E_a = 0.35 (e_a - e_d) (1 + \frac{v}{2}) \text{ millimeter/day} \dots\dots\dots\dots (2)$$

where e_d--------actual absolute humidity (millimeter).

e_a--------saturation humidity under average temperatures (millimeter).

v--------wind speed (meter.second).

H--------equilibrium value of radiation derived from the following formula:

$$H = 0.95R_a (0.18 + 0.55S) - \sigma Ta^4 (0.56 - 0.99 \sqrt{e_d})$$

$$(0.10 + 0.90S) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

where S--------percentage of sunshine.

R_a--------theoretical value of solar radiation (under the condition of no atmosphere)

T--------average absolute temperature.

σ--------the Stefan-Boltzmann constant

After H is obtained by this formula it is divided by 59 (heat potential of evaporation), and then converted to millimeters.

The evaporative strength of water surface (E_o) is equal to the greatest amount of evaporation of a sufficiently large area of water surface. This amount multiplied by a definite proportional coefficient is the evaporative strength of the field. The evaporative strength of the field is theoretically the greatest possible amount of evaporation of the field. Actually, it should be equivalent to the amount of evaporation of the field when the soil is sufficiently moist, i.e., when the amount of moisture in the soil does not constitute a limiting factor. The evaporative strength of the field $E_t = fE_o$. The coefficient f of grasslands in southern England measured by Penman was: 0.7 in spring and autumn, 0.6 in winter, and 0.8 in summer. The average over the several months of growth of winter wheat is 0.73.

The amount of water needed by crops, strictly speaking, should be the sum of the amount of evapotranspiration from the surface of the leaves and the amount of evaporation among individual plants under appropriate conditions of soil moisture maintained during a particular growth stage of the crop. During some growth stages of crops, maintenance of sufficient water supply in the soil may not be necessary. At this time, the amount of water needed and the

evaporative strength of the field may not be consistent numerically, for example, during the period of maturation of wheat. But in the majority of situations, a sufficient amount of soil moisture can be taken as the appropriate condition for the growth of crops. At this time, the amount of water needed by crops is equivalent numerically to the evaporative strength of the field. In this task we used data of the amount of water actually needed at some experimental irrigation stations to determine the value of f of winter wheat fields of the regions being studied. We believe the evaporative strength of the field thus computed has already been corrected for the difference between it and the amount of water needed during different stages (of growth) and the evaporative strength is numerically equal to the amount of water needed.

We have found the values of f for the various stages of growth of winter wheat:

Stages of growth	Sowing-Tillering	Tillering-Freezing	Freezing-Returning Green	Returning Green-Jointing	Jointing-Heading	Heading-Maturation
coefficient	0.7	0.6	0.3-0.6	0.5	1.0	1.0

Comparison of the data of actual measurements of the amount of water needed during each stage of growth and records of the days of growth of winter wheat in Beijing and regions of the Wei-Hui canal experimental irrigation station (Wugong, Shaanxi Province), the Jing-Hui Canal experimental irrigation station (Jingyang, Shaanxi Province), and the Administrative Bureau for guiding water of the Yellow River for irrigation (Xinxiang, Henan Province), and the evaporative strength of the field calculated from meteorological data observed and measured at the localities, and the values of f of each growth stage listed above (Figure 1) shows that a close relationship exists.

When this group of coefficients was being determined, we used a medium level yield. The weighted average over the entire growth period was between 0.64 and 0.72. To facilitate comparison and simplify computation, we used the coefficient f = 0.7 for the entire growth period when we studied the natural water supply for winter wheat in the five northern provinces. The evaporative strength of the field calculated from this coefficient is about equivalent to the amount of water needed by winter wheat to produce a medium level yield (about 300 to 400 jin/mu in Beijing).

2. Natural Supply of Water During the Growth Period

The amount of rainfall during the growth period of winter wheat in the regions studied was small, generally only between 100 and 200 millimeters. Considering only the amount of rainfall, it is far short of the amount of water needed by wheat. But winter wheat plays an important role in agricultural production in the north, and in some regions, it is a relatively stable
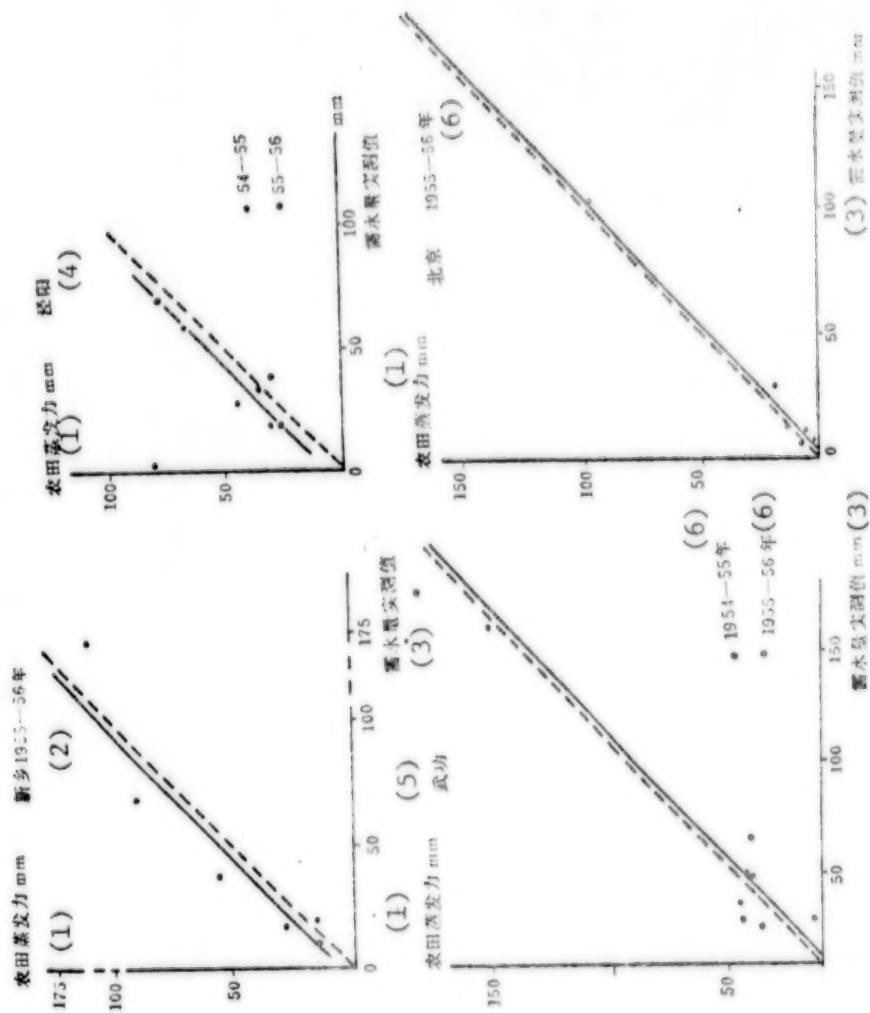
Figure 1. Comparison of the computed values and the actually measured values of the amount of water needed during each stage of growth of winter wheat.

Key: (1) evaporative strength of the field mm   (4) Jingyang
      (2) xinxiang 1955-56   (5) Wugong
      (3) actually measured amount of water needed (6) Beijing 1955-56

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yielding crop. One reason is because a large amount of rain water of summer and autumn is stored in the soil layers for use by winter wheat. Generally at the time of sowing of winter wheat, the amount of effective moisture in a soil layer of one meter may reach between 150 and 250 millimeters. This amount of water constitutes the major portion of the amount of water consumed during the entire growth period of winter wheat. This is the basis for the farmers' saying: "After harvesting wheat, there will be moisture in the soil the year after next," and the method of determining the proportion of planting wheat according to the amount of summer rain. Therefore, we have used the following formula of estimation to compute the source of natural water during the growth period of winter wheat in the regions being studied:

Amount of water supply--amount of rainfall during the growth period + the base moisture at the time of sowing of wheat

The growth period of winter wheat in northern China is basically the dry season of the year. Stormy rain is seldomly seen. Therefore we have deleted the term for loss by runoff. In addition, we also deleted the effect of supplementary underground water. Generally speaking, this will not cause any problems at places where the level of underground water is deeper than 2 to 3 meters. This also facilitates the differentiation of ecological zones of large areas and thus the calculations do not take this term into consideration. But since a rather large portion of the productive regions of wheat in the northern regions of our nation is located in places where the underground water level is rather high, it will be necessary in the future to study this as a special topic.

Thus, the key problem in calculating the amount of water supply during the growth period is to find a method to compute the amount of base moisture in the soil before sowing. The amount of base moisture is greatly affected by the forecrop. Since each planting system is different, the factors affecting base moisture are complex. To facilitate comparison of the natural water resources of each locality, we have uniformly disregarded the forecrop, and based on the characteristic of a larger amount of rainfall in summer and autumn in the regions being studied, we have assumed that the amount of moisture in the soil during the rainy season has reached the amount of retention of water of the field. Then we calculate the estimated amount of the content of base moisture according to the amount of consumption and evaporation of water from the exposed ground.

The method of calculating the amount of evaporation from exposed ground we used was the Turk formula. This formula was obtained from analysis of massive amounts of data of various regions of the world including China. We contrasted the calculated values with the numerical data observed and measured by the ГГИ-500 evaporator in Beijing in 1958 at our academy's agrometeorological research laboratory and obtained good results as shown in Figure 2.
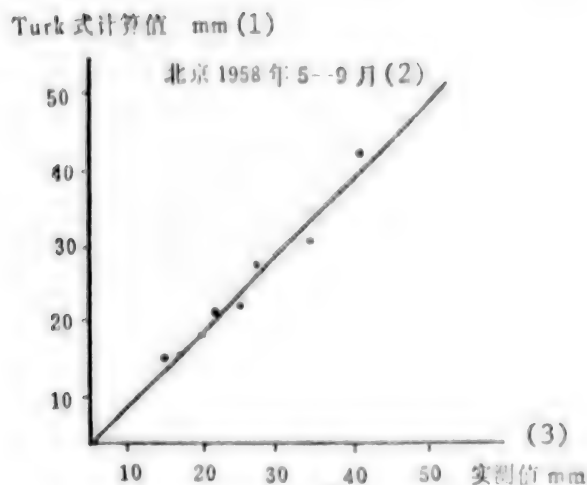
Figure 2. Comparison of the actually measured amount of evaporation from the soil and the amount of evaporation from the soil computed by the Turk formula

Key: (1) values calculated by the Turk formula mm
     (2) Beijing May to September, 1958
     (3) Actually measured values mm

The Turk formula for calculating the amount of evaporation of a 10-day period from exposed ground is as follows:

$$E = \frac{p + a}{1 + (\frac{p + a}{e})^2} \quad \text{millimeter}$$

where $e = \frac{1}{15}$ $(t + 2)$ $\sqrt{R}$

and E-------amount of evaporation from exposed ground in a 10-day period.
    p-------amount of rainfall in a 10-day period.
    t-------average temperature in a 10-day period.
    R-------value of solar radiation.

In the formula, a is a constant. When the water content of the soil equals the amount of retention of water in the field, a = 12. When the amount of water contained in the soil is less than the amount of retention of water of the field by Δ millimeters, a = 40 - Δ, but when (40 - Δ) is greater than 12, the value of a used is still 12 The smallest value for a is 1, where (40 - Δ) $\leq$ 0, a = 1.

In the formula, R = Ra (0.18 + 0.55S) calorie/day.

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Symbols in this formula mean: Ra -- theoretical value of solar radiation under conditions where there is no atmosphere; S -- percentage of sunshine.

The calculations begin when the rainy season is about to end, from about the last 10 days of August to the middle 10 days of September, determined by the actual amount of rainfall of the year. First assume that the content of moisture in the soil during the rainy season has reached the amount of retention of water of the field, then if the amount of evaporation in the present 10-day period is less than the amount of rainfall ($E < P$) and the rainfall not only evaporates but the remainder is lost through leakage and leaching, and the wetness due to the amount of water retained in the fields is still maintained, then this indicates the rainy season has not ended. Calculation of E for the next 10-day period is continued. If $E > P$ at this time, i.e., when the amount of rainfall is insufficient for evaporation and consumption, and the deficient portion is supplied by the moisture in the soil, then, the amount of moisture in the soil will drop to below the amount of retention of water in the field, $E - P = \Delta$. The numerical deficiency is the difference between the actual content of water in the soil and the amount of water retention of the field (abbreviated as the soil's moisture deficiency in the following).

Such calculations over successive 10-day periods until the 10-day period when the wheat is sown, and the accumulation of the soil's moisture deficiency of each 10-day period together give the total amount of the soil's moisture deficiency. Let A be the content of effective moisture when the amount of water retained by the soil layer (in calculations we take the depth to be 1 meter), usable by the root system of wheat has reached the volume of water retainable by the soil, then the content of effective base moisture is $(A - \Sigma\Delta)$. The amount of natural water supply usable by wheat throughout the entire growth period is $P + (A - \Sigma\Delta)$.

3. Conflict Between the Need and the Supply of Moisture

As described above, when the condition of the crop does change, the amount of moisture needed can be determined by meteorological conditions. At the same time, the natural conditions for the supply of moisture can also be determined by the two factors of weather and soil. A comparison of the quantities of these two factors is useful in understanding the sources of natural moisture in a large area, because in addition to the two sources of natural moisture from rainfall and the amount of water stored in the soil which can be utilized by the crop, the deficiency must be made up by artificial irrigation. In actuality, surface water and underground water which can be used for irrigation at present still originate mostly from within the climatic regions which we have discussed except for a few exceptions (such as guiding water from the Yellow River into irrigational regions), therefore irrigation is still mainly limited by climatic conditions.

The difference between the total amount of natural water supply usable during the growth period and the amount of water needed during the same period has been labeled as the difference of moisture supply and demand here by the author. We have used the above method to calculate the average difference of moisture supply and demand over many years for the five northern

provinces. The purpose is mainly and hopefully to aid the study of the situation of natural water resources for winter wheat in a large area.

In actual calculations, we used observed and measured data of 780 stations, years from 1951 to 1960, taken at 78 meteorological observatories (stations) in the five provinces (Shanxi, Hebei, Shandong, Henan, Shaanxi) which included the northern region and part of the northwestern region. The above method was used to calculate the amount of rainfall, the amount of water needed (evaporative strength of the field) and the difference of moisture supply and demand during the growth period of winter wheat, and the distribution maps (see Figures 3, 4, 5) of the amount of rainfall, the amount of water needed (evaporative strength of the field) and the difference of moisture supply and demand for winter wheat in the Yellow River-Hui River-Haihe River region were drawn. When calculating the amount of base moisture, the greatest amount of effective moisture content of each locality was taken mainly according to determinations made from soil texture indicated in the "Atlas of Pedological Maps of the Plains of North China" compiled cooperatively by the pedological team of the Chinese Academy of Sciences and the main pedological investigation team of the Beijing Survey and Design Institute of the Ministry of Water Conservancy. But soil conditions at the various stations in Shandong Province were taken from investigative data of the agrometeorological laboratory of this institute.
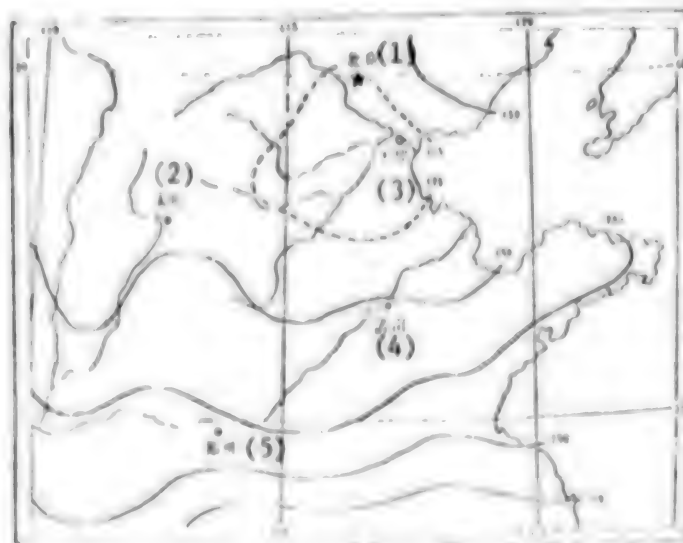
Figure 3. Map of distribution of rainfall during the growth period
(millimeters)

Key: (1) Beijing   (3) Tianjin   (5) Zhengzhou
      (2) Taiyuan   (4) Jinan
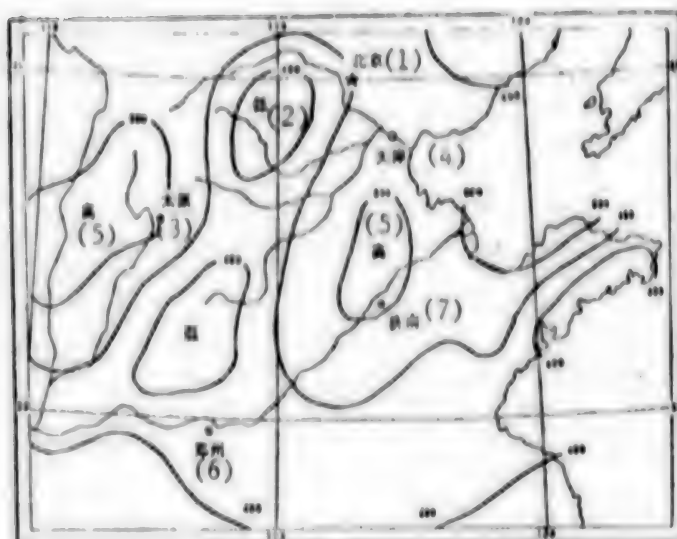
Figure 4. Map of distribution of the amount of water needed (evaporative strength of the field) from sowing to harvest (millimeters)

Key (to map above and below)

(1)	Beijing	(4)	Tianjin	(7)	Jinan
(2)	low	(5)	high		
(3)	Taiyuan	(6)	Zhengzhou		

Figure 5. Map of distribution of the difference of moisture supply and demand (millimeters)

It can be seen from the diagrams that the general trend of the distribution of the amount of rainfall during the growth period of winter wheat in the Yellow River-Hui River-Haihe River region is an increase in amount from north to south, increasing from below 150 millimeters north of the Yellow River to about 400 millimeters in the Hui River valley. South of the Yellow River, the isoline mov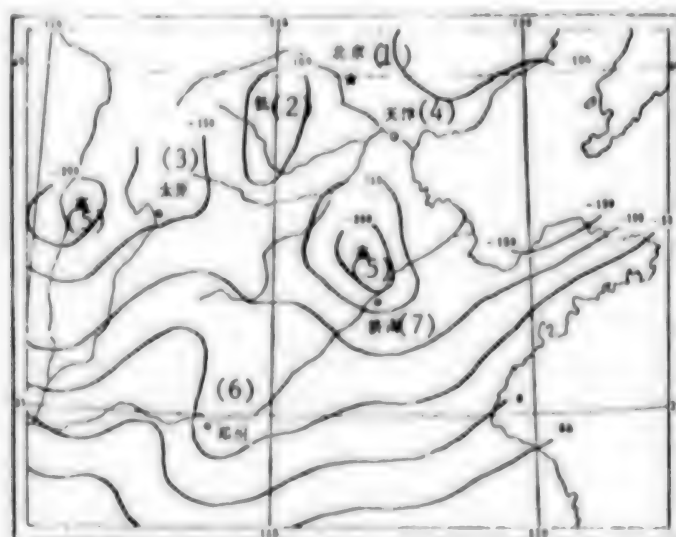es basically from east to west and curves only on the two sides of Taihangshan because of the affect of mountain topography. Moisture brought in from the Pacific Ocean falls in larger amounts as rain before the mountain, thus the eastern side of Taihangshan has more rainfall and the rainfall on the other two sides is less. But in the region from the northern to the northeastern regions of Hebei, the growth period is prolonged and the total amount of rainfall in the growth period increases slightly. Thus, the entire north China Plain, including most of Hebei Province, northern Shandong Province and part of Shanxi Province, is a region where the amount of rainfall is relatively small, only 125 millimeters or less. Further west to Gansu Province, the amount of rainfall drops drastically again and the isoline suddenly bends southward.

The evaporative strength of the field basically is not distributed according to latitudes in most of the regions of the Yellow River-Hui River-Haihe River region. The region of northwest Shandong Province and Cangzhou and Hengshui in Hebei Province is a center of high evaporative strength, and the region from the western part of Shanxi to the regions of Suide and Mizhi in northern Shaanxi is another center of rather high evaporative strength. Along the Taihangshan isoline, the evaporative strength is lower because of high topography and low temperatures.

The distribution of the difference of moisture supply and demand during the growth period of winter wheat in this region is shown in Figure 5. It can be seen from the diagram that in most of north China and the northwest region the difference of moisture supply and demand is negative in value. The zero line of the difference of moisture supply and demand begins from about 35° latitude on the eastern coast and extends along the border separating Shandong and Jiangsu provinces in an east to west direction. It extends westward to Henan Province, shifts towards the south to about 35° latitude, and crosses the central part of Henan Province. It reaches the foot of the Taihangshan on the west and bends northward forming a "ridge," then it swings south around the border of Shanxi Province to the neighborhood of Dali and Huayin in Shaanxi Province and then crosses through the central part of Shaanxi Province. Only in the southern half of Henan which is south of this line (approximately south of Xuchang) and the central and southern regions of Shaanxi including the central regions of the province is the difference of moisture supply and demand slightly higher than zero. This means, to realize a medium level yield of wheat, the average amount of natural water supply in normal years during the period of growth of wheat in these areas is slightly higher than the amount of water needed by wheat. In most regions in north China and the northwest including almost the entire province of Shandong, the whole province of Hebei, the whole province of Shanxi, the northern part of Shaanxi and the northern half of Henan, the difference of moisture supply and demand is negative in value. This means that according

to the situation in normal years, the source of natural water is insufficient for wheat to produce a medium level yield in these regions. In particular, there are two dry centers. One is the region from the northwest of Shandong to southern Hebei, and at the center of this region the difference of moisture supply and demand reaches above 200 millimeters. The other region is near Suide and Mizhi in northern Shaanxi where the amount of deficiency of water is also about 200 millimeters. This also means that for winter wheat to produce a medium level yield, the deficiency of water throughout the growth period of winter wheat in these regions is above 200 millimeters (approximately equivalent to 130 to 150 square meters of water [2455 3055]). In the absolute majority of regions of north China, to raise the unit area yield of wheat to a higher level requires irrigation.

What we have already analyzed is only the situation under the ordinary level of agricultural techniques. The masses of farmers in the north of our nation have rich experiences in the cultivation of wheat and conservation and preserving moisture in the soil. Many incidents of high yields indicate that the potential for increased yield of wheat in the northern regions is great. Although the deficiency of water during the growth period of wheat in these regions is a disadvantageous condition, yet at the same time this season's sunshine is strong, the difference between day and night is great, weather conditions are stable, and few sudden natural disasters occur and hit, and these are favorable conditions. In some regions where the soil is deeper, the amount of water retained by the soil is greater, the underground water sources are richer and more natural disasters occur in summer, wheat is even more important as a food and grain crop. In combating the unfavorable condition--dryness, the potential for developing moisture can still be exploited in two aspects:

(1) Increasing the amount of retention of water in the soil in summer and autumn as much as possible: The amount of water preserved in the soil constitutes half or more than half the amount of water consumed by wheat. Especially in the mid-stream and down stream regions of the Yellow River and the Haihe River valley region, the amount of rainfall during the growing season of winter wheat is small and variations are great. If it were not for the characteristic of a concentrated rainfall of large amounts in summer and autumn so that wheat can utilize the water stored in the soil layers and that the yield has a definite stability, it can be imagined the sowing area of wheat in the north of our nation would not be that large. History has shaped many planting measures which precisely favor storage of more water, for example, the custom of summer rest of the past in the Hanyuan region of central Shaanxi.

(2) Reduce the total amount of water needed by wheat by various means: In the regions studied in this article, the air is dry, wind blows frequently, evaporative strength is strong, the plants are short, small and sparse during the growth period of winter wheat, therefore the amount of ineffective evaporation from the soil is great. Related data indicate the amount of such waste may be as much as 1/3 of the total amount of water consumed. The total amount of water consumed can be reduced by reducing evaporation

of this part of the water. Such methods as raking wheat and plowing wheat under frequently used by the masses have been proven to be very effective in reducing ineffective evaporation and increasing yield.

But, computational analysis of this article shows that in most of the regions of northern China and the northwest, the supply of natural water, generally speaking, is unfavorable to winter wheat. Even in producing medium level yield, the absolute majority of the regions must rely on irrigation, and underground water which is used for irrigation in most of the regions is similarly limited by meteorological conditions in the amount of water reserves, and these are not perpetual springs that are inexhaustible. Thus, the sowing area of winter wheat must be reasonably arranged. Some years ago, some regions blindly emphasized planting of plenty of flour and rice crops and the area of winter wheat was overly expanded. And to seek numerical yield, fertilizers were applied and water was irrigated regardless of cost, often creating the situation in which the cost of purchasing wheat was higher than the income. This created losses for the farmer as well as the state. To a certain extent, it was also the result of a lack of careful consideration of natural conditions.

II.

Penman's formula for evaporative strength can be solved for two terms:

$$E_o = \frac{H\Delta}{\Delta + r} + \frac{rEa}{\Delta + r}$$ obtained from equation (1), and from the

energy viewpoint, the first term $\frac{1H\Delta}{\Delta + r}$ can be regarded as the consumption

by evaporation due to the energy brought by radiation. The second term

$\frac{rEa}{\Delta + r}$ can be regarded as consumption by evaporation caused by the energy

supplied by the exchange of random flow. Thus the first term can represent the radiative component of evaporative strength. The second term can represent the dynamic component of evaporative strength.

It is known from equation (3) that the equilibrium value of radiation H is mainly related to the percentage of sunshine and temperature of the locality, and humidity of the air also has a definite but very small effect. Therefore the constituent part of evaporative strength is not related to man-made factors in the ecological environment on the ground surface in a big way.

The Ea in the second term, according to equation (2), $Ea = 0.35 (ea - e_d)$ $(1 + \frac{v}{2})$, increases as the saturation of differential humidity in the air and the wind speed increase. Thus this component and the ecological environment of the ground surface are related to a greater extent.

We have calculated the radiative component of evaporative strength (abbreviated as radiative evaporative strength) and the dynamic component (abbreviated as dynamic evaporative strength) of each region separately and drawn up figures 6 to 11.
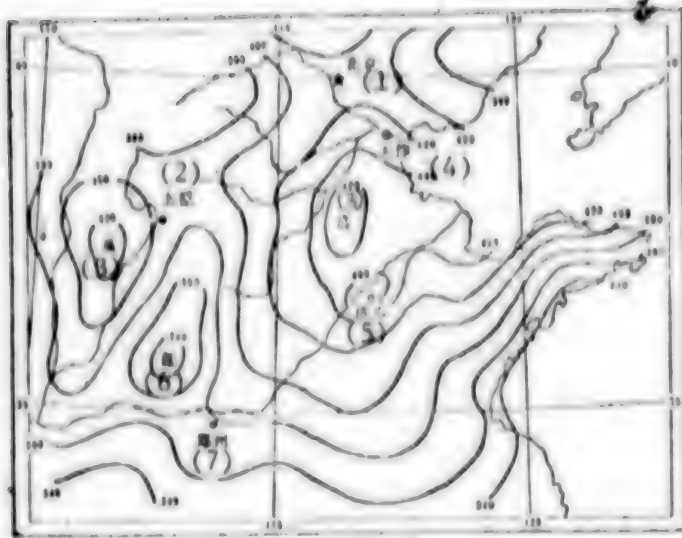
Figure 6. Total evaporative strength
in spring (millimeters)

Key: (1) Beijing   (5) Jinan
      (2) Taiyuan   (6) low
      (3) high   (7) Zhengzhou
      (4) Tianjin

Figure 7. Dynamic evaporation
in spring (millimeters)
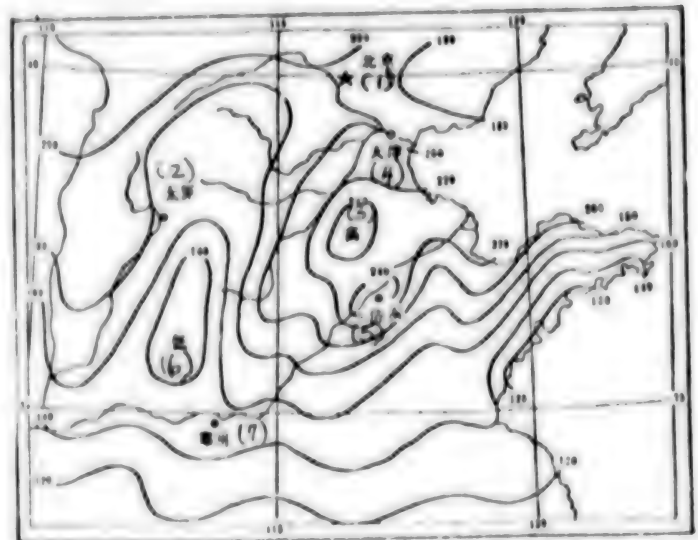
Key same as above

Figure 8. Radiative evapora-
tive strength in spring
(millimeters)

Key same as above

Figure 9. Total evapora-
tive strength in autumn
(millimeters)

Key: (1) Beijing
     (2) Tianjin
     (3) Taiyuan
     (4) low
     (5) high
     (6) Jinan
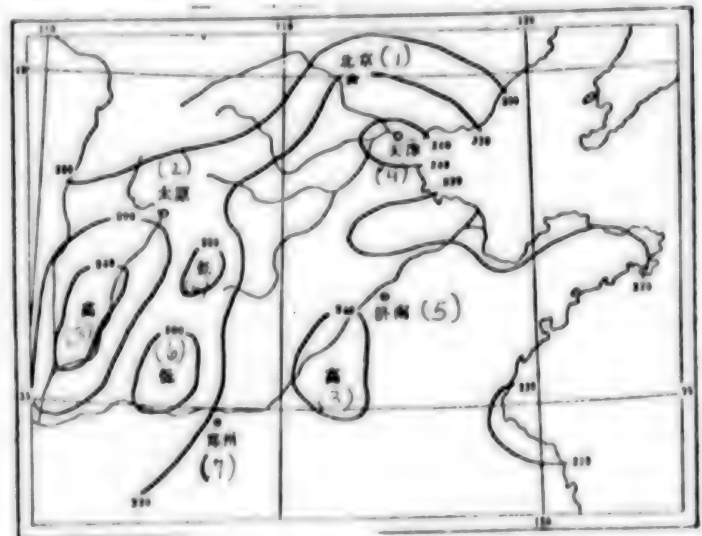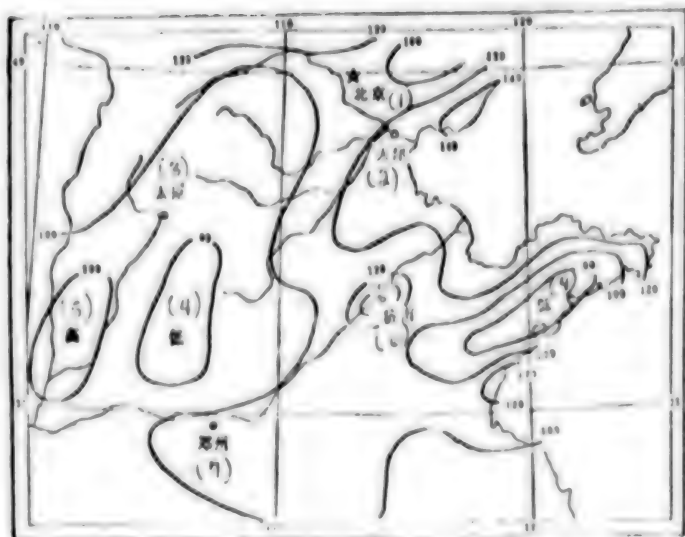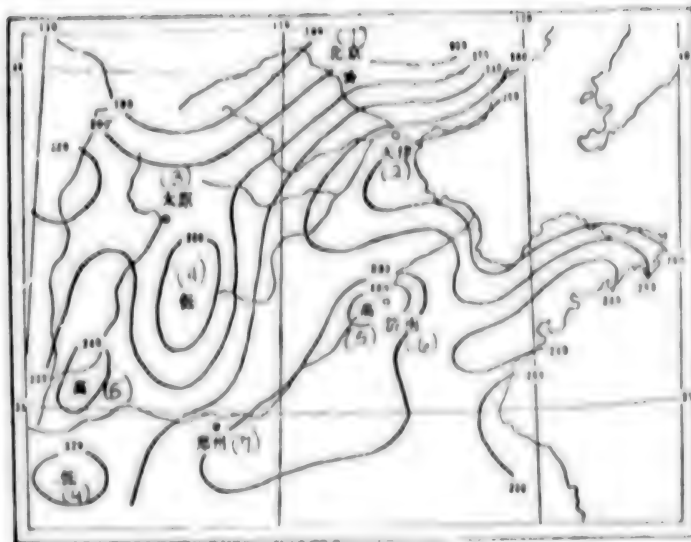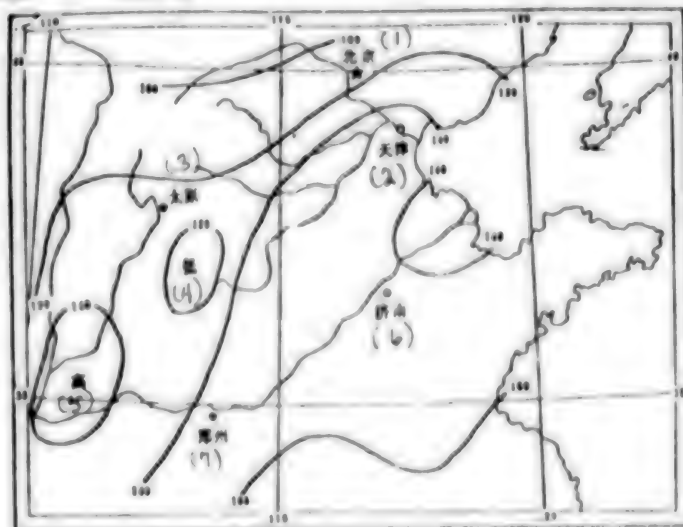   (7) Zhengzhou

Figure 10. Dynamic evapora-
tive strength in autumn
(millimeters)

Key same as above.

Figure 11. Radiative
evaporative strength in
autumn (millimeters)

Key same as above.

It can be seen from the diagrams that in the northern regions of our nation, the consumption of water caused by dynamic factors constitutes a very large proportion of the consumption of water by evaporation in autumn, winter and spring. Especially in the two provinces of Shandong and Hebei and the northern part of Henan, the dynamic evaporative strength directly proportional to wind speed and dryness of the air can constitute half or more than half of the total evaporative strength. It is significant in pointing out this fact because in some regions of north China and the northwest, spring drought frequently occurs mainly because the evaporative strength of the field greatly surpasses the amount of rainfall in this season. If it is possible to reduce the amount of evaporation, then it would be possible to alleviate the drought. The northern regions of our nation have a long agricultural history, a large population, and natural forests and vegetation have been seriously destroyed. There are no windbreakers, humidity of the air is not regulated. These are some of the important reasons why this region is plagued by many disasters. This point has been emphasized by researchers in many fields, and it is proven again by our calculations using the formula for evaporative strength and the distribution diagrams of the various components of evaporative strength drawn up by us. It seems that one of the fundamental measures to reform the ecological conditions of this region is forestation, greening of all barren land and bare mountain ranges which can be afforested.

III.

What is the relationship between the supply of moisture and the average unit area yield of winter wheat of each reagion? To clearly understand this problem, we conducted an analytical study of the data of the annual average per mu yield over a large area taking special districts as units over the years 1951 to 1960.

First we compared the relationships between unit area yield and the difference of moisture supply and demand during the entire growth period. In some places, this relationship was obvious, and as the difference of moisture supply and demand increases, the unit area yield drops, such as in the Beijing prefecture and the Baoding special district.

The yield of each special district is expressed as a percentage of the average over many years. The percentages are graduated every 10 percent. The coordinates of each dot are averaged. Then the broken lines formed by the dots representing each region show similar patterns, i.e., as the difference of moisture supply and demand reduces, the yield tends to increase (See Figure 12). The few exceptional years all had their particular causes, for example, in some regions of the south in 1953, severe frost caused a reduction in yield. In 1957, an overabundance of autumn rain and low temperatures in spring occurred. In 1950, some regions suffered from widespread rust disease because of dampness and rain in spring.

It can be seen from this that the total amount of moisture received and expended during the growth period has a definite relationship with the amount

of yield. But on the other hand, the distribution of the supply of water
during each stage (of growth) must not be neglected. We sought further for
a relationship between the moisture (content) of each period (of growth)
and the yield. At first we used the ratio of the amount of rainfall vs the
amount of evaporation, or the difference between the amounts of rainfall
and evaporation, for our calculations but we discovered the results were not
very different from calculations using only the amount of rainfall. This
may be because the annual percentage of change in the amount of evaporation
during each stage (of growth) is much smaller than the percentage of change
in the amount of rainfall.

The supply of water of each stage (of growth) is classified into the follow
ing: (1) Base moisture; (2) Rainfall in October and November; (3) Rainfall
in December, January and February; (4) Rainfall in March; (5) Rainfall in
April and (6) Rainfall in May. The relationship between these and the
yield was separately sought. We analyzed data of average unit yield over a
large area from 1952 to 1957 (1951-1960 for individual localities) in the
five special districts of Shijiazhuang in Hebei Province et al, Beijing
prefecture, four special districts of Xinxiang in Henan Province et al,
five special districts of Humin in Shandong Province et al, three prefectures
of Jinnan in Shanxi Province et al, Suide and Yulin in Shaanxi Province and
Pingliang in Gansu Province. We discovered by analysis that since the period
before and after the spring heading time are the critical periods of need
for water, and since the time of growth at each locality is different, the
amount of yield in some places is most closely related to the amount of rain
in April, and the amount of yield in other places is most closely related
to the amount of rain in May. After contrast, the borders of these two re-
gions could generally be drawn according to the "late maturing winter wheat
regions of the northern part of north China" and the "early maturing winter
wheat regions of the southern part of north China" classified in "The Science
of Wheat Cultivation in China."

The relative ratios between the percentage of change of unit area yield and
the amount of rainfall of each stage (of growth) and the base moisture ob-
tained statistically for these two regions separately are as follows:
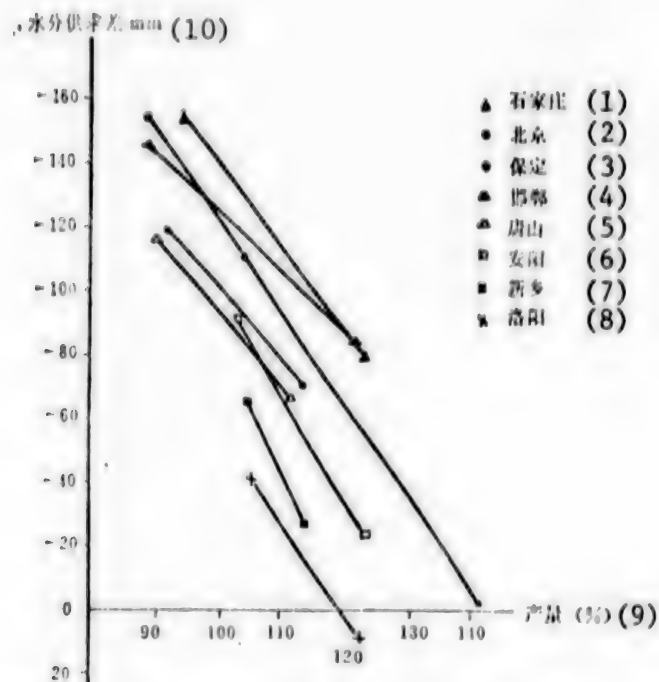
Figure 12. Relationship between average yield of special districts and differences of moisture supply and demand.

Key: (1) Shijiazhuang   (6) Anyang
      (2) Beijing   (7) Xinxiang
      (3) Baoding   (8) Luoyang
      (4) Handan   (9) Yield %
      (5) Tangshan   (10) Difference of moisture supply and demand mm

相关水 供水 区域 (2) (1) (3)	底 墒 (4)	10,11月降水 (5)	12,1,2月降水 (6)	3 月 降 水 (7)	4 月 降 水 (8)	5 月降水 (9)
中 熟 区 (10)	0.65	0.61	0.46	0.52	0.76	0.14
晚 熟 区 (11)	0.62	0.C9	0.55	0.41	0.66	0.71

Key: (1) water supply   (7) Rainfall in March
      (2) relative ratios   (8) Rainfall in April
      (3) Regions   (9) Rainfall in May
      (4) Base moisture   (10) Intermediate maturing region
      (5) Rainfall in October   (11) Late maturing region
          and November
      (6) Rainfall in December,
          January and February

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The properties of these relationships in the two large regions are consistent. The following few points can be pointed out:

1. The effect of the content of base moisture at time of sowing upon the amount of yield is great. Good base moisture produces high yield.

2. The effect of the amount of rainfall in May in the northern wheat regions upon the amount of yield is great. The amount of rainfall in April in the southern wheat region upon the amount of yield of wheat is the greatest. The amount of yield increases as the amount of rainfall increases, but an overly abundant amount of rainfall deviating from the amount of ordinary years will cause a drop in the amount of yield.

3. The amount of rainfall in autumn (October and November) has a negative effect upon yield. This is true in both large regions. We studied the situation in years of bumper harvests (unit area yield above that of ordinary years by an average of between 10 and 40 percent) and years of poor harvests (unit area yield lower than that of ordinary years by an average of 10 and 30 percent), and discovered that the kind of distribution of rainfall is visibly different in years of bumper harvests and in years of poor harvests. Basically, in years of bumper harvests, less rain falls in the early period and more rain falls in the later period (from the time appropriate for sowing of wheat to the time of harvest, not including summer and autumn rainfall before sowing). In years of poor harvests, more rain falls in the early period and less falls in the later period. But the critical time during the later period is different in the two large regions. In the intermediate maturing region, the critical time is in April or earlier. If rain is scarce in April, more rain in May will not be able to make up for lost yield (such as in 1955). In the late maturing region, the critical time is in May.

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CSO: 4007

PROTEIN CONTENT OF SINGLE GRAIN OF RICE ESTIMATED

[Article by Wu Pingli [0702 1627 3810], Gao Quanson [7559 3123 5549], Chen Hansheng [7115 3352 3932] of the Paddy Rice Breeding Scientific Research Group of the Guizhou Agricultural College, and Shan Youliang [0830 0645 6156], He Zhaofan [0149 3564 5400], Niu Aizhen [3662 1947 4176] and Du Wei [2629 5633] of the Biochemical Nutrition Research Laboratory of the Guizhou Agricultural College: "Quick Determination of Protein Content and Screening Technique for Single Grains in Paddy Rice Breeding"]

[Text] In our nation's work in paddy rice breeding, a more suitable protein screening technique had not yet been found up to now, thus there have been some difficulties in the progress in breeding high protein rice. Therefore we have conducted studies in the use of trinitrobenzene sulfonic acid (TNBS)* staining to determine the protein content in the seed grain based on the need to breed high protein paddy rice, and we have obtained preliminary results. This technique is simple, fast, and requires only 10 to 20 seeds for measuring the content of protein and it does not destroy the seeds' strength of germination. It is a more suitable screening technique for analyzing high protein rice varieties and it has created conditions for the breeding of high protein rice.

Principles of the Method of Measuring Protein Content by Trinitrobenzene Sulfonic Acid Staining

The principle of using trinitrobenzene sulfonic acid staining to measure the content of protein is based on the reaction between trinitrobenzene sulfonic acid and the N terminal α-amino group and the ε-amino group of remnant lysine groups to form orange colored trinitrobenzolized proteins:

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* Produced by the Dongfeng Biochemical Reagents Plant of the Shanghai Biochemistry Research Institute.

(Lysine ε-amino group)

$$CH_2NH_2$$

$$H_2N\ \overset{R'}{\underset{H}{C}}-CONH-\overset{R''}{\underset{H}{C}}-CO-NH-\overset{(CH_2)_3}{\underset{H}{C}}-CO-\Big[NH-\overset{R}{\underset{H}{C}}-CO-\Big]NH-\overset{R'''}{\underset{n}{C}}-COOH$$

(N terminal
α-amino
group)

$$+\ O_2N-\overset{NO_2}{\underset{NO_2}{\bigcirc}}-SO_3H$$

protein

$$\xrightarrow{NaHCO_3}\ O_2N-\overset{NO_2}{\underset{NO_2}{\bigcirc}}-HN-\overset{R'}{\underset{H}{C}}-CONH-\overset{R''}{\underset{H}{C}}-CO-NH$$

$$CH_2NH-\overset{NO_2}{\underset{NO_2}{\bigcirc}}-NO_2$$

$$(CH_2)_3$$

$$-\overset{}{\underset{H}{C}}-CO-\Big[NH-\overset{R}{\underset{H}{C}}-CO-\Big]_n NH-\overset{R'''}{\underset{H}{C}}-COOH$$

Trinitrobenzolized protein
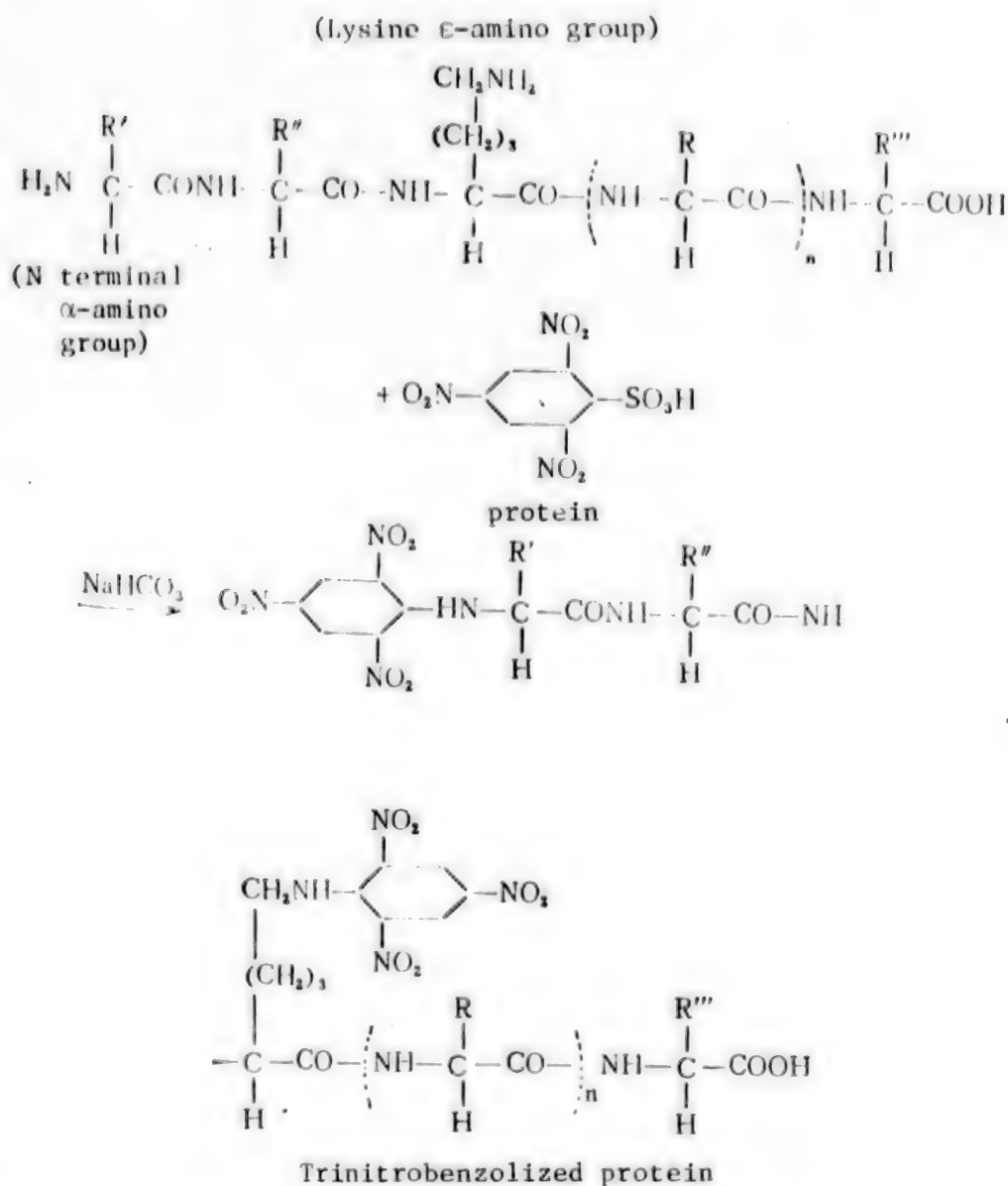
Among the 22 kinds of amino acids of conjugated amino acids, 19 contain the α-amino group. Thus any one of the N terminal α-amino group of the amino acids of conjugated protein can react with trinitrobenzene sulfonic acid. The ε-amino group of remnant lysine groups constitutes a far larger proportion than the N terminal α-amino group in protein molecules. Thus in the staining reaction of protein by trinitrobenzene sulfonic acid, the ε-amino groups play the major role. Thus, whether the amount of the content of lysine can reflect the amount of the content of protein is a relationship which must first be understood clearly. In 1978 we used the TNBS reagent produced by our own college's biochemical nutrition research laboratory and we used a color comparison method designed on our own and the Kjeldahl method of measuring mitrogen to determine the contents of protein and lysine in 197 local varieties of paddy rice and 17 successfully bred varieties in our province (Table 1).

Table 1 Mutual Relationship Between the Content of Lysine and the Content of Protein in Coarse Rice

(含水量12%)

1) 蛋白质含量(%) 2) 分组	5) 品种数	6) 蛋 白 质 含 量(%) 总 7) 量 / 平 8) 均		9) 赖 氨 酸 含 量(%) 总 量 / 平 均		赖氨酸/蛋白质 (%) 10)
5.00 – 5.99	1	5.85	5.85	0.19	0.19	3.24
6.00 – 6.99	32	214.43	6.70	6.62	0.21	3.13
7.00 – 7.99	71	528.16	7.44	15.57	0.22	2.95
8.00 – 8.99	42	345.81	8.24	10.40	0.25	3.03
9.00 – 9.99	28	264.61	9.45	7.83	0.28	2.96
10.00 – 10.99	24	253.97	10.58	7.25	0.30	2.94
11.00 – 11.99	11	126.50	11.50	3.69	0.34	2.95
12.00 – 12.99	3	37.03	12.34	1.14	0.38	3.08
13.00 – 13.99	2	26.91	13.45	0.76	0.38	2.82
3) 合 计	214	1765.12		53.45		
4) 平 均						3.02

Key:
1. Protein content (%)
2. Group
3. Total
4. Average
5. Number of varieties
6. Protein content (%)
7. Total
8. Average
9. Content of lysine (%)
10. Lysine/protein (%)

It can be seen that a linear relationship (Figure 1) exists between the content of lysine and the content of protein in coarse paddy rice. The regressive coefficient is extremely visible (t = 13.45, P < 0.01). Lysine constitutes a definite proportion in conjugated protein, about 30 percent (Table 1), and the amount of the content of lysine can basically indicate the amount of the content of protein. The higher the protein content is, the more abundant are the N terminal α-amino groups and the ε-amino groups of the remnant lysine groups, and the darker the stain by trinitrobenzene sulfonic acid. Conversely, the lower the protein content, the fewer the N terminal α-amino groups and ε-amino groups of the remnant lysine groups, and the lighter the stain by trinitrobenzene sulfonic acid.

According to the above principle, we first used seeds from six paddy rice varieties of known protein content classified as having a high, medium and low content of protein. The seeds were cut open and soaked in trinitrobenzene sulfonic acid reagent for staining and observation. We discovered that the darkness or lightness of the stain was consistent with the high or low content of protein. A high content of protein was indicated by a dark stain and a low content of protein was indicated by a light stain. To further prove the reliability of the method of determining the protein content by trinitrobenzene sulfonic acid staining, we selected 16 pieces of material already tested for protein content by the staining method and used the Kjeldahl method to measure the content of protein and compared the results of the two methods (Table 2). The results of seven pieces coincided.

The results of six pieces of material were different by less than 1 percentage point. Accurate determinations were made in 13 pieces of material. Only three pieces of material differed by 1 to 3 higher percentage points, with an accuracy reaching 81.2 percent. Therefore, the use of trinitrobenzene sulfonic acid staining to determine the content of protein as a screening technique in the breeding of high protein paddy rice is feasible. In addition, we also experimented with five wheat varieties (three of high protein content). The darkness and lightness of the stain also coincided with the high and low contents of protein. Thus, determination of the content of protein by trinitrobenzene sulfonic acid staining can also be used in the breeding of high protein varieties of other crops.

content of lysine (%)
. represents actual content of protein
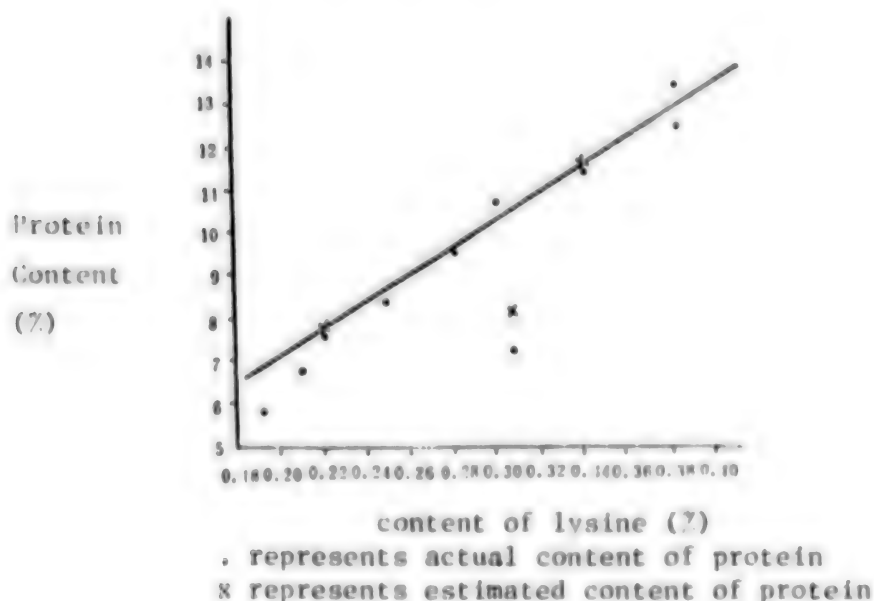x represents estimated content of protein

Figure 1   Linear regression of the content
of protein in coarse rice

Table 2 Results of Measuring the Content of Protein by Trinitrobenzene Sulfonic Acid Staining and Confirmation of Analysis by the Kjeldahl Method

1) 编号	2) 材料名称	绑定三硝基苯磺酸产品测定的蛋白质含量（%）3)（含水量12%）	4) 凯氏法测定的蛋白质含量（%） 5) 烘干时的含量	6) 折合水量为12%时的含量	两法相比蛋白质含量之差（%）7)
1	33 1	7 + 0.5	8.65	7.61	- 0.11
2	B) 科 梗	8 + 0.5	8.87	8.61	- 0.11
3	1024 11	8 + 0.5	7.62	6.71	+ 0.79
4	1024 11	8 - 0	8.22	7.23	+ 0.77
5	934 1	8 0	8.02	7.06	+ 0.94
6	33 1	9 10	10.77	9.48	— 同
7	32 3	9 10	11.54	10.16	- 0.16
8	1165	9 10	8.90	7.83	+ 1.17
9	72 2	10 + 0.5	13.01	11.45	- 0.95
10	934 3	10 + 0.5	7.49	6.56	+ 2.94
11	390	10 + 0.5	8.99	7.91	+ 1.59
12	32 2	10 11	11.56	10.17	— 同13)
13	207	10 11	11.64	10.24	— 同
14	二九南 1 GA×R 9)	13以上 12)	16.08	14.13	— 同
15	二九南 1 GA×R 10)	13以上	16.74	14.75	— 同
16	珍山 97 A×R 11)	13以上	15.84	13.94	— 同

Key:
1. Number
2. Name of material
3. Content of protein determined by the trinitrobenzene sulfonic acid staining (%) (12% water content)
4. Determination of protein content by the Kjeldahl Method (%)
5. Content when dried
6. Conversion to equivalent content when content of water is 12%
7. Comparative difference in the protein content of the two methods (%)
8. Kegeng
9. Er jiu nan No 1 A x R1
10. Er jiu nan No 1 A x R6
11. Zhenshan 97 A x R1
12. Above 13
13. Same

The Method of Measuring the Content of Protein in Paddy Rice by Trinitrobenzene Sulfonic Acid Staining

I. Preparation of the Reagent

First take 1 gram of trinitrobenzene sulfonic acid and dilute it with 100 milliliters of water to make a 1 percent solution. Take 40 grams of sodium bicarbonate and dilute it with 1000 milliliters of water to make a 4 percent solution. Mix one part of trinitrobenzene sulfonic acid solution with three parts of sodium bicarbonate solution for use. The mixed reagent should be used within 3 days. The mixture when not in use for a long time will lose its effectiveness.

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2. Set Up Control Varieties

In using this method, a control variety must be set up as a standard for color comparison. A high protein variety (low limit) and a low protein variety (high limit) are used as control varieties. We used "Zhen zhu ai No 11" as the high protein control variety with a protein content of 12.06 percent and a lysine content of 0.42 percent. The low protein control variety used was the "Geng xiang No 1" with a protein content of 8.71 percent and a lysine content of 0.26 percent.

3. Preparation of the Seed Grain

The seed grains are separated into groups of ten seeds each. To each group must be added seeds of the control variety. The bags containing the seeds must be labeled by the number of the small glass test tubes. Ten to 20 seeds (10 seeds of the variety, 20 seeds of the hybrid offspring) which have matured under normal conditions are taken from each batch of the material and the control varieties. A single edged razor is used to cut the seeds across at about 1/4 from the top. The surface of the cut must be even. The part of the seed with the embryo must be kept and placed inside similarly numbered glass test tubes. If red rice or purple rice is used, the color of the pericarp will seriously affect the showing of the color (of the stain). Therefore the hull must first be removed. The pericarp at the tip of the rice grain must be cut away and then the grain is cut across for use in staining. Under this condition, the seed grains of the control variety must also be prepared the same way.

4. Staining

Use a rubber suction tube to syphon about 2 milliliters of trinitrobenzene sulfonic acid reagent and place the solution into the small glass test tubes until all 12 test tubes have been filled. Each tube is then shaken several times so that the grains become submerged in the reagent. Then the tubes are placed inside a thermotank of 40°C for the staining reaction to take place. Since the freshly mixed reagent's staining reaction is fast, and the stale reagent's staining reaction is slower, the duration of the staining reaction is usually from 3 to 5 hours. The orange color shown by the seeds of the high protein varieties serving as control varieties is taken as the standard. The temperature inside the thermotank must not be higher than 40°C so that the strength of germination of the seeds is not affected and that the selection of high protein single grains can be conducted. If a thermotank is not available, the staining reaction will also take place under room temperature but the duration of the staining reaction will be much longer.

5. Washing and Color Comparison

After the staining reaction is complete, the solution in the test tube is thrown away and the remaining contents are washed with clean water twice. The water is then discarded. When making color comparisons, the cut surfaces of the seeds must maintain a relative wetness. The seeds must not be allowed

to dry out or part of the seed must not change to white and thus affect the color comparison. First place the seeds of the high protein control variety and the low protein control variety inside the small holes on the two sides of the color comparison board. Then the seeds of the material to be tested are placed in the holes in the center of the color comparison board. Observations and contrasts are done with a magnifying glass of magnification less than 10 for color comparison to determine the content of protein. The protein content can be classified as high, medium and low. A protein content under 9 percent is classified as low, a content between 9 and 11 percent is classified as medium, and a content of above 12 percent is classified as high. The range of the content of protein can be estimated by the darkness or the lightness of the color.

Discussion

1. The Value of Application in Paddy Rice Breeding

The use of trinitrobenzene sulfonic acid staining to determine the content of protein has the following advantages:

(1) Determination of the content of protein is basically accurate and reliable.

(2) The determination of the content of protein without destroying the strength of germination of the seeds is an advantage which is not possessed by the various kinds of methods of chemical analysis such as the Kjeldahl method of determination of nitrogen. The percentage of germination of the seeds after undergoing staining reaction by the trinitrobenzene sulfonic acid reagent is 96.2 percent. The seeds can grow into seedlings normally if the cuts on the seeds are sealed with cellulose dissolved in acetone and the seeds are then sown. This method has a more applicable value in screening single grains of high protein content.

(3) The method is simple, fast and inexpensive. It does not require expensive instruments and equipment. It is easily performed. One person can measure 80 samples a day. We measured a total of 1,342 pieces of material and screened over 6,000 seeds for single seed selection using only 2 grams of trinitrobenzene sulfonic acid and spending about 40 yuan.

(4) The amount of seeds used is minute. Only 10 to 20 seeds are sufficient for making measurements.

2. Accuracy of Determination of the Content of Protein by Trinitrobenzene Sulfonic Acid Staining

After confirmation by the Kjeldahl method of nitrogen determination, the accuracy of determining the content of protein by trinitrobenzene sulfonic acid staining reached 81.2 percent. Inaccurate measurements of three pieces of material showed a deviation of 1 to 3 percentage points from the actual content of protein. The reason was due to the fact that generally the content of lysine in protein is about 3 percent, and when the proportional content of lysine in certain varieties surpasses 3 percent, the content of

protein determined by the staining method would be higher than that determined by the Kjeldahl method. Conversely, when the content of lysine is proportionally below 3 percent, the protein content as measured by the staining method would be lower than that measured by the Kjeldahl method. Therefore this method of measuring the protein content is not very accurate but as a screening technique in the process of breeding high protein paddy rice, it has a definite applicative value.

To raise the accuracy of this method, the control varieties must be selected on a strict basis. Attention should be paid to selecting varieties with a proportional lysine content in the protein within the range of 3 percent ± 0.1.

3. Practical Application in Paddy Rice Breeding

To breed high protein rice, there must first be high protein parent varieties. For this we have used trinitrobenzene sulfonic acid staining to test and determine the protein content of 835 domestic and foreign paddy rice varieties, and have preliminarily selected 97 varieties with a protein content of between 10 and 11 percent and 13 high protein varieties with a protein content of above 12 percent. This method was also used to determine the protein content of 507 hybrid offspring and to preliminarily select 17 hybrid materials with a protein content of between 10 and 11 percent.

In the course of using trinitrobenzene sulfonic acid staining to measure the protein content in paddy rice, we have also discovered that the protein content of different seed grains of the same variety or of the same single hybrid plant differs, generally by about 1 to 3 percentage points. Accordingly, we screened for single seed grains with a high protein content and selected single grains of 59 hybrid parents. From this we selected 575 high protein seed grains. They have been sown and have germinated. They will be used as the parent for hybridization in 1979 to produce high protein plants. We also selected single grains of the 17 hybrid offspring with a protein content of between 10 and 11 percent. From the 6,025 seeds selected we obtained 968 high protein seed grains by screening.

In addition, we also observed in the absolute majority of seed grains that the staining reaction on the cut surface showed a darker color on the outer layer and a lighter color on the inner layer. This is because more protein is distributed in the outer layer of the endosperm and less in the inner layer. In the course of finishing polished rice, more protein is lost. Therefore some people have suggested that it would be most ideal to selectively breed varieties whose protein is distributed evenly in the endosperm, and the use of trinitrobenzene sulfonic acid staining can realize this ideal. At present we have already obtained 261 seed grains with a more even distribution of protein by screening over 20,000 seeds of 1,342 pieces of material. This has provided the material basis and the screening technique for the cultivation of ideal varieties of high protein paddy rice.

DOWNGRADING OF MILLET DISCUSSED

Beijing RENMIN RIBAO in Chinese 27 Jan 80 p 2

[Article by Xiang Yin [6763 7299]]

[Text] In the past in the northern farm villages, one could always eat
fragrant millet or hot and fresh millet gruel. But for several years this
has not been possible. Many places that produced a lot of millet have planted
less, and it has even become difficult for pregnant women to have millet gruel
when they want some.

Why has millet become scarce in recent years? This is because in the past
some people believed millet was a "low yield crop." No matter how people
liked it, needed it, it was not to be planted too abundantly. So people
had to sacrifice their love [for it] and let high-yield crops take its place.
At that time, farmers of some places did not have the right to decide for
themselves. What was to be planted and how it was to be planted were all
arranged by the higher authorities, and millet naturally became scarce year
after year.

Millet, this agricultural crop, has a long history in our nation. Tang
dynasty poet Dufu once said: "Rice flows like sap and millet is clean and
white, public and private granaries are all richly filled." The millet
mentioned in these lines is millet. It can be seen that at that time millent
was a major food and grain crop. During the years of the revolutionary war,
millet also contributed greatly. Did we not often say defecting the enemies
at home and abroad relied on "millet plus rifles?" Now, to use the label
of "low-yield crop" to downgrade its value is truly unfair.

Yet, planting must take yield into consideration. At present, the yield
of millet is slightly low, this is true. But from the point of view of
development, if ways can be found to improve the varieties and elevate the
techniques of cultivation, it is also possible to achieve high yields. There
are many places at present which have fields that produce 1,000 jin per mu
already. Also, our calculations cannot always be oriented towards the guide-
lines and unilaterally seek to produce (a high) unit area yield of a certain
crop. The quality and economic value of the product and the people's need
for the product must also be considered. Millet contains a rich content of

fat, protein and vitamins. Its nutritional value is high. This is one reason the people like it. Its straw and husks are good feed for domesticated animals and birds. Planting plenty of millet will benefit development of animal husbandry. This is also its advantage. In addition, people's customs are different and their needs are different. A popular saying is: "There are those who like turnips and those who like green vegetables, each to his own." Generally speaking, southerners love to eat rice, northerners love to eat sorghum (not the coarse hybrid sorghum), the Zang nationality loves to eat zanba made of roasted naked barley flour. Northerners and northwesterners love to eat millet. These various regional customs and the masses' need for certain food and grain varieties should undoubtedly be respected, and efforts should be made to satisfy such needs.

The articles of agricultural policy established by the Third Plenary Session of the 11th Party Central Committee opened a new page in hastening the development of agriculture. In particular, the article respecting the right of decision making by the production brigades was even more welcomed by the broad basic level cadres and the peasants. Now, more and more leading comrades have already begun to emphasize this problem. In arranging for food and grain production, they can weigh the advantages and disadvantages, they can choose and they can discard. They have taken notice of the combination of crop varieties according to regional characteristics and the living customs of the masses so that simultaneous emphasis is given to both the raising of the yield of agricultural crops and the needs in people's livelihood. Production developed, the masses are very happy, the market is livelier. As long as this persists, food grain crops of regional flavor will surely be able to compete across our nation's expansive land. People of the entire nation will quickly be able to eat food and grains of the many varieties that they like.

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CSO: 4007

ATTENTION TO VARIETAL COMBINATIONS IN FIELD PRODUCTION URGED

Beijing RENMIN RIBAO in Chinese 27 Jan 80 p 2

[Article by NEW CHINA NEWS reporter Son Hongxiang [1327 3263 4382]: "Attention Should Be Given to Combinations of Varieties in Food Grain Production"]

[Text] Food grain production should be based on the needs of the society and the people's livelihood, be uniformly prepared, emphasize all aspects and arranged rationally. This reporter has often heard such comments from commune members during reporting assignments in farm villages in the Shanghai suburbs.

In recent years, some food grain varieties profoundly liked by the masses in the Shanghai surburban region have become scarce day by day. Some are on the verge of extinction, for example, such grains as thin rice, fragrant geng rice, Sugeng rice, bloody (red) glutinous rice, food grains other than wheat and rice such as soybeans, green beans, white broad beans, large dark red beans etc. Planting area and yield of corn, the king of feed crops, have also been greatly reduced, and yet the planting area and yield of poorer quality barley and xian rice have visibly increased. Comparison of 1975 and 1965 shows the amount of xian rice purchased from the entire suburban region rose from over 284 million jin to over 785 million jin. The amount of geng rice purchased dropped from 694.95 million jin to 6.35 million jin. At present, the trend of homogenizing food grain varieties has not changed.

Homogenizing food grain varieties affects the multiple needs for food grains of people's livelihood and the special needs of society. As the standards of the people's livelihood rise and as foreign trade and tourism develop, this kind of conflict between supply and demand will become more and more outstanding.

Why does this situation emerge? Besides adapting to the demand for triple cropping crop arrangement, there is another very important reason. It is the unilateral pursuit of unit area yield, and when selling grain as an item of requisite purchase by the state, everything is calculated on the basis of unprocessed food grains. Communes and brigades thus are willing to expand only crops that produce higher yields of unprocessed food grains, disregarding the needs of the livelihood of the masses.

Some experts in agricultural economy in Shanghai point out that this way of doing things, which disregards practical utility value and economic value, is not in keeping with socialist economic principles. A survey conducted in 1978 by the Liansan Brigade of the Huating Commune of Jiading County showed the yield of such food grains of the triple cropping system by 7.18 percent while the yields of finished (processed) food grains differ only by 0.27 percent, but the cost is lower by about 19 percent. According to prices of food grains on the international market, thin rice and thick geng rice, which are quality rice, command about 80 percent more in price than xian rice. A ton of xian rice can only be bartered for 1.5 tons of wheat while a ton of thin rice or thick geng rice can be bartered for 2.7 tons of wheat.

Many members of the masses of cadres in the Shanghai suburban region believe that in the adjustment of the national economy, production of food grains must be practical and realistic. Emphasis should be on concrete results. Structuring of the varieties should be adjusted, some rare and precious varieties of food grains and some varieties with high practical value should be appropriately planted. Some comrades suggest that in the task of requisition purchases of food grains by the state, calculations based on unprocessed food grains should be changed to calculations based on finished food grains. At the same time, reasonable care should be given to those varieties of food grains of superior quality in the price of requisition by the state, to protect and mobilize the peasants' activeness in production.

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HEREDITY PATTERNS OF ECONOMIC PROPERTIES OF RICE STUDIED

Guangzhou GUANGDONG NONGYE KEXUE [GUANGDONG AGRICULTURAL SCIENCES] in
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[Article by the Genetics Advanced Studies Class of Zhongshan University,
and written and guided by Comrade Li Baojian [2621 1405 0256]: "Preliminary
Study of the Hereditary Patterns of Major Economic Characteristics of Paddy
Rice"]

[Text] To further elevate the effectiveness of hybridization of superior
varieties, better develop utilization of heterosis of paddy rice and explore
the hereditary pattern of major economic characteristics of paddy rice in the
F_2 generation and the possibility of utilizing heterosis, we conducted re-
search on this subject.

I. Method of Experiment

In 1975, we selected "Ai jiao nan te," "Ai zi zhan" and "Di jiao wu jian,"
paddy rice varieties which possessed the "dwarf factor" as parents and
crossed them with many other parents to form many pairs and combinations.
We conducted a more systematic study of the biological characteristics of
the parents and their first generation hybrids of the late crop of 1975. The
second generation hybrids of the three combinations "Ai jiao nan te" x "Du zi
xian", "Ai zi zhan" x "Tuo tuo pu", and "Di jiao wu jiao" x "Yu hua zhan"
planted as early crops in 1976, and the second generation hybrids of the
combinations "Di jiao wu jian" x "Ai zi zhan", "2150" x "Xiao jia huo"
("IR1529-68-3") and "Fu bao ai" x "Du zi xian" planted as the late crops in
the same year were studied. Two hundred plants from each combination were
selected for systematic investigation at fixed localities and for seed tests.
Accurate data were also selected for statistical analysis and calculations.

II. Results of Experiment

(1) Separation of Some Major Economic Characteristics of Paddy Rice in
Second Generation Hybrids

1. Plant Height

"Ai jiao nan te" x "Du zi xian" combination: The average plant height of "Ai jiao nan te" was 69 centimeters, that of "Du zi xian" was 130.7 centimeters. Plants of F_1 averaged 120 centimeters, those of F_2 averaged 122.85 centimeters. Among the F_2 plants that actually emerged, the ratio of tall stemmed plants versus short stemmed plants was 144:44. The distribution frequency of plant heights had two peaks. Plant height was manifested mainly as a qualitative characteristic. Results of x^2 tests were consistent with the 3:1 pattern. This proved that the characteristic of plant height is controlled by a pair of genes and dwarfing characteristic is controlled by a recessive gene.

"Ai zi zhan" x "Tuo tuo pu" combination: The average plant height of "Ai zi zhan" was 83.4 centimeters, that of "Tuo tuo pu" was 147 centimeters, the average plant height of the F_1 plants was 124.6 centimeters and that of F_2 plants was 116.8 centimeters. Among the F_2 plants that actually emerged, the ratio of tall stemmed plants versus short stemmed plants was 146:49. The characteristic of the distribution frequency of the plant heights was the same as the above. Results of x^2 tests were consistent with the 3:1 pattern.

"Di jiao wu jian" x "Ye hua zhan" combination: The average plant height of "Di jiao wu jian" was 91 centimeters, that of "Ye hua zhan" was 126.7 centimeters. The F_1 plants averaged 124.6 centimeters and the F_2 plants averaged 132.15 centimeters. Among the F_2 plants that actually emerged, the ratio of tall stemmed plants versus short stemmed plants was 120:35. The characteristic of the distribution frequency of the plant heights was the same as the above. Results of x^2 tests were consistent with the 3:1 pattern.

"Di jiao wu jian" x "Ai zhong shui tian gu" combination: The average plant height of "Di jiao wu jian" was 91 centimeters and that of "Ai zhong shui tian gu" was 86.2 centimeters. The F_1 plants averaged 104.7 centimeters. Among the F_2 plants that actually emerged, the ratio of tall stemmed plants versus short stemmed plants was 67:127, with a majority of short stemmed plants. Among the F_2 plants of the combination "Qing xiao jin zao" x "IR24", the ratio of tall stemmed plants versus short stemmed plants was 42:92, with short stemmed plants constituting the majority. Because of a possible cumulative effect of secondary genes (or modified genes) in hybrids, plants which are taller than both parents have emerged among both the F_1 and F_2 plants.

Among the combination of the late crop experiments, results of analysis of the F_2 generation of the combination "Fu bao ai" x "Ye hua zhan" remains to be repeated.

The "2150" x "Xiao jia huo" combination: Among the F_2 plants that actually emerged, the ratio of tall stemmed plants versus short stemmed plants was 120:49. The characteristic of the distribution frequency of plant heights was the same as that of the first combination. The ratio of separation among F_2 plants was consistent with the 3:1 separation pattern.

It can be seen from the above that in the breeding of the plant types of "Ai jiao nan te", "Ai zi zhan" and "Di jiao wu jian", dwarfing is controlled by

one recessive gene. This recessive gene was still able to retain its definite independence through multiple crossing and back crossing and being transmitted to many generations, and it was still being inherited as manifested in plants of "Xiao jia huo".

2. Growth Period

(1) The growth period of F_2 plants showed widespread variation. For example, in the combination "Di jiao wu jian" x "Ye hua zhan", the heading time of F_2 plants was prolonged from 105 days to between 150 and 160 days. It can be seen that a widespread separation of the characteristic growth period occurred. The maturation period of F_2 plants generally manifested a continuous variation. Its separation generally formed a normal curve distribution or an off normal curve distribution. The number of days for heading was controlled by many genes.

(2) In the three early x late combinations, such as "Di jiao wu jian" x "Ai zhong shui tian gu" and "Fu bao ai" x "Du zi xian", the F_2 plants planted as late crop had a distinctly fewer average number of days for heading than those of the parents. For example, the average number of days for heading of the F_2 plants of the combination "Di jiao wu jian" x "Ai zhong shui tian gu" was 85 days, and some single plants were even able to head within a period of more than 60 days while the parents separately required 92 and 110 days to head. The F_2 plants showed superior dominance, thus it is possible in this way to select early maturing paddy rice which basically possesses the plant type and the leaf type of late rice. Conversely, in the early x early combination, if the parents were planted as late crop, and the F_2 plants were planted as the summer crop, then the heading date of F_2 plants will be much later than that of the parents, such as the case of the offspring of the combination "Di jiao wu jian" x "Ye hua zhan". But if one of the parents is an early maturing parent, then some plants of the F_2 generation will mature slightly earlier than the late maturing parent, for example, the offspring of the combination "Qing xiao jin zao" x "IR24". In all of the above cases, the characteristic of widespread separation of the growth period of F_2 plants does not change, for example, the number of days for heading of F_2 plants of the combination "2150" x "Xiao jia huo" can vary from 70 days up to 115 days.

(3) Separation of the growth period of F_2 plants of parents whose growth periods are close is generally less. For example, the maturation dates of the parents of the combination "Ai zi zhan" x "Tuo tuo pu" differ only by a few days and the growth period of over 60 percent of the plants of the F_2 generation is concentrated within the range of between 125.1 days and 130 days. But if the growth periods of the parents differ greatly, distribution of the heading times of F_2 will be more dispersed (from 105 days to 160 days), such as in the combination "Di jiao wu jian" x "Ye hua zhan". The difference between the growth periods of the two parents is 18 days.

(4) The periods of maturation of tall and short plants of the F_2 hybrid combinations of "Fu bao ai" x "Du zi xian" are not visibly different. The average heading period of the tall stemmed plants of the F_2 generation

requires 83.1 days with a variation coefficient of 12.4 percent. The average heading period of short stemmed plants of the F_2 generation is 78.33 days and the variation coefficient is 13.48 percent. Thus, height of the plants and maturation periods are not fundamentally related.

3. Highest Number of Tillers of a Single Plant

The results of experiments of the following three combinations were used to analyze the hereditary pattern of the highest number of tillers of the single plant in the F_2 generation.

"Ai zi zhan" x "Tuo tuo pu" combination: The highest average number of tillers of the single plant of "Ai zi zhan" was 27, that of "Tuo tuo pu" was 25.2, that of F_1 plants was 25.6, and that of F_2 plants was 15.33. The distribution frequency of plants with this characteristic was a normal curve, indicating the characteristic is controlled by many genes.

"Di jiao wu jian" x "Ye hua zhan" combination: The highest average number of tillers of the single plant of "Di jiao wu jian" was 16.6, that of "Ye hua zhan" was 21.4, that of F_1 plants was 34.2, and that of F_2 plants was 9.88. The distribution frequency characteristic was the same as above.

"Di jiao wu jian" x "Ai zhong shui tian gu": The highest average number of tillers of the single plant of "Ai zhong shui tian gu" was 16.1, that of the F_1 plants was 29, that of the F_2 plants was 16.51, close to the numbers for "Di jiao wu jian". The characteristic of distribution frequency was also the same as the two combinations above. Similarly, when early maturing parents "Qing xiao jin zao" and "Hong mei zao" were crossed with "IR24," the distribution frequency of the characteristic of the highest number of tillers of single plants of the F_2 generation showed the normal curve characteristic.

It can be seen from the above that the characteristic of the highest average number of tillers is also a quantitative characteristic controlled by many genes. When a tall stemmed parent x short stemmed parent is combined, the highest average number of tillers of F_2 plants is often visibly lower than that of F_1 plants. But among some combinations of short stemmed parent x short stemmed parent, it seems possible that a definite level of tillering ability can be maintained.

4. The Number of Effective Tillers of a Single Plant

Genetic characteristics of the number of effective tillers of second generation plants of the following four combinations were studied.

"Ai zi zhan" x "Tuo tuo pu" combination: The average number of effective tillers of the single plant of "Ai zi zhan" was 11.4, that of "Tuo tuo pu" was 15, that of F_1 plants was 16, and that of F_2 plants was 7.42. The distribution of this characteristic was a normal curve but very few (F_2 plants) surpassed those of F_1 (in the number of effective tillers). Thus the superior dominance in the number of effective tillers manifested by F_1 plants visibly dropped in the F_2 generation.

"Di jiao wu jian" x "Ye hua zhan" combination: The average number of effective tillers of the single plant of "Di jiao wu jian" was 9.8, that of "Ye hua zhan" was 11.3, that of the F_1 plants was 13.5, and that of the F_2 plants was 5.54. The distribution characteristic of B superiority of this characteristic drops in the F_2 generation and is basically similar to the situation above.

"Di jiao wu jian" x "Ai zhong shui tian gu" combination: The average number of effective tillers of the single plant of "Ai zhong shui tian gu" was 8.8, that of F_1 plants was 15.4 and that of the F_2 plants was 9.00. The distribution characteristic was the same as the two combinations above but the average number of effective tillers of the single plant was between the numbers of the two parents. This situation is rare.

"Fu bao ai" x "Du zi xian" combination: The average number of effective tillers of the single plant of "Fu bao ai" was 12.2, that of "Du zi xian" was 14.5, that of F_1 plants was 16.8. The F_2 plants were divided into a tall stemmed group and a short stemmed group for measurement. The number of effective tillers of single plants of the tall stemmed group was 9.46 and that of the short stemmed group was 9.02. The difference was not great and the distribution was a normal curve. The numbers of effective tillers of single plants of the F_2 generation of the combinations "Qing xiao jin zao" x "IR24" and "Hong mei zao" x "IR24" showed a normal curve (distribution).

The above seems to indicate the number of effective tillers of the single plant is a quantitative characteristic controlled by many genes. Although F_1 shows a definite superiority (mostly manifested as superior dominance), superiority in the F_2 generation of tall stemmed x short stemmed combinations and even the majority of short stemmed x short stemmed combinations visibly drops. But in individual short stemmed x short stemmed combinations, there is the possibility of finding plants with a characteristic between those of the parents, and definite superiority over the parent with a weak tillering ability can be manifested.

5. Length of Panicles

The genetic characteristics of the length of panicles were analyzed in the following F_2 hybrid combinations.

"Di jiao wu jian" x "Ai zhong shui tian gu" combination: The average length of the panicles of "Di jiao wu jian" was 22.45 centimeters, that of "Ai zhong shui tian gu" was 21.75 centimeters, that of F_1 plants was 25.95 centimeters and that of F_2 plants was 24.07 centimeters. The distribution of the characteristic length of panicles in the F_2 generation is a normal curve. This indicates that it is a quantitative characteristic controlled by many genes. But it must be pointed out that in the F_2 generation, 84 percent of the plants still retain a characteristic panicle length superior to those of the parents. This is worth our attention.

"Fu bao ai" x "Du zi xian" combination: The average length of panicle of
"Fu bao ai" was 18.57 centimeters, that of "Du zi xian" was 25.55 centimeters
and that of the F_1 plants was 23.31 centimeters. The average length of
panicle of F_2 plants was measured for the tall stemmed group and the short
stemmed group. The average length of panicle of the tall stemmed group was
23.26 centimeters. The average length of panicles of the short stemmed group
was 21.78 centimeters. It can be seen that the characteristic lengths of
panicles of both the tall stemmed group and the short stemmed group formed a
normal curve distribution. This indicates that it is controlled by many genes.
The characteristic length of panicles of the F_1 generation of this combination
is not manifested as a superior dominance or an obvious dominance. The length
only approaches that of the longer panicles of the parents. The length of
panicles in the F_2 generation generally surpasses that of the short panicles
of the parents, but the length of the panicles of the tall stemmed group is
longer. About 50 percent of the plants in this group have longer panicles
than the length of panicles of F_1 plants. This indicates the characteristic
length of panicles can possess a definite superiority.

Genetic manifestations of the characteristic length of panicles of other
combinations such as "IR24" x "Qing xiao jin zao" and "IR24" x "Hong mei
zao" in the F_2 generation are generally similar to the above.

6.   Total Number of Grains on Each Main Panicle

"Di jiao wu jian" x "Ye hua zhan" combination: The average total number of
grains on the main panicle of "Di jiao wu jian" was 139.5, that of "Ye hua
zhan" was 156, that of F_1 plants was 178, manifested as a superior dominance,
and that of F_2 plants was 155.6. Among the F_2 plants, the parental charac-
teristic of having more number of grains on the main panicle is still mani-
fested as a dominant characteristic. The total number of grains on the main
panicles of 43 percent of the F_2 plants surpassed the total number of grains
on the main panicle of "Ye hua zhan", manifesting a persistence of superior
dominance. The total number of grains on the main panicles of the other 24
percent of the plants of the F_2 generation surpassed the total number of
grains on the main panicles of the plants of the F_1 generation, maintaining
a greater heterosis. The distribution of the characteristic of the total
number of grains on the main panicle of the plants of the F_2 generation showed
a near normal curve. This indicates that this characteristic is similarly a
quantitative characteristic controlled by many genes.

"Fu bao ai" x "Du zi xian" combination: The average total number of grains
on the main panicle of "Fu bao ai" was 140, that of "Du zi xian" was 231.6
and that of F_1 plants was 247. The F_2 plants were divided into a tall
stemmed group and a short stemmed group. The average total number of grains
on the main panicles of the tall stemmed group of plants of the F_2 generation
was 115.2, that of the short stemmed group of plants was 132.2. The distribu-
tion and genetic characteristic were the same as the above. The results of
experiment of this combination showed that although the total number of grains
of F_1 plants generally possessed superior dominance, the total number of grains
on the main panicle might not have maintained heterosis.

The distribution characteristic of the total number of grains on the main panicle of the F_2 plants of other combinations such as "Ai zi zhan" x "Tuo tuo pu" was the same as above. Although F_2 plants were planted as summer crop, the average total number of grains on the main panicle was 119, lower than that of both parents ("Ai zi zhan" had 156.5 grains, "Tuo tuo pu" had 133 grains). The average number of grains on the main panicle of F_2 plants of the two combinations "Qing xiao jin zao" x "IR24" and "Hong mei zao" x "IR24" was 148 and 164 respectively. The distributions were more dispersed than those above. This indicates that perhaps there are a larger number of genes controlling this characteristic.

7. Total Number of Grains on Each Tillers Panicle

"Ai jiao nan te" x "Du zi xian" combination: The total number of grains on each tiller panicle of "Ai jiao nan te" was 197.5, that of "Du zi xian" was 148.9, that of the F_1 plants was between those parents, and that of the F_2 plants was 134.41, manifested as a dominant superiority. This characteristic showed a continuous variation among F_2 plants and had an off normal curve. Above 56 percent of the tiller panicles of F_2 plants showed superior dominance.

"Ai zi zhan" x "Tuo tuo pu" combination: The average number of grains on each tiller panicle of "Ai zi zhan" was 98.5, that of "Tuo tuo pu" was 101.7, that of F_1 plants was 125.2 and that of F_2 plants was 76.04, lower than those of the parents. The genetic characteristic was basically the same as that of the above combination but showed a negative superior dominance.

"Di jiao wu jian" x "Ye hua zhan" combination: The average number of grains on each tiller panicle of "Di jiao wu jian" was 112, that of "Ye hua zhan" was 79.4, that of F_1 plants was 132 and that of F_2 plants was 103.1, manifesting incomplete dominance. The distribution characteristic among F_2 plants was a normal curve, indicating it is a quantitative characteristic controlled by many genes.

"Fu bao ai" x "Du zi xian" combination: The average number of grains on each tiller panicle of "Fu bao ai" was 103.9, that of "Du zi xian" was 148.9 and that of F_1 plants was 164.8. The F_2 plants were divided into the tall stemmed group and the short stemmed group. The average number of grains on each tiller panicle of the tall stemmed group was 115.5 and that of the short stemmed group was 107.7. The genetic characteristic was similar to the above.

The average number of grains on each tiller panicle of F_2 plants of the combinations "Qing xiao jin zao" x "IR24" and "Hong mei zao" x "IR24" was also between 110 and 125 grains, manifesting a definite superiority and its range of distribution was rather wide.

8. Fruiting Percentage of the Single Plant

"Di jiao wu jian" x "Ai zhong shui tian gu" combination: The fruiting percentage of the main panicle of "Di jiao wu jian" was 77 percent, and the

fruiting percentage of the tiller panicles was 84 percent. The fruiting percentage of the main and tiller panicles of "Ai zhong shui tian gu" was 86.7 and 94.3 percent respectively. The average fruiting percentage of the main and tiller panicles of the two parents "Di jiao wu jian" and "Ai zhong shui tian gu" was 85.4 percent. The average fruiting percentage of the main and tiller panicles of the plants of the F_1 generation was 79.05 percent and that of the plants of F_2 generation was similar. The distribution frequency of the characteristic of fruiting percentage among F_2 plants was an off normal curve. The fruiting percentage of 57.6 percent of the F_2 plants surpassed that of the F_1 plants.

The "2150" x "Xiao jia huo" combination: The distribution frequency of the characteristic of fruiting percentage among the F_2 plants also was an off normal curve. The number of plants with the most distribution was slightly higher than the number of plants of this combination with the most distribution.

The fruiting percentage of the single plant of the F_2 generation of the combination "Qing xiao jin zao" x "IR24" reached 83.45 percent. The fruiting percentage of the single plant of the F_2 generation of the combination "Hong mei zao" x "IR24" reached 88.21 percent. This indicated that as long as the combination is appropriate, the fruiting percentage of tiller panicles may also be higher. The distribution characteristic was the same as above.

9. Thousand Grain Weight

The genetic characteristics of the thousand grain weights of F_2 plants of six combinations were analyzed.

"Ai jiao nan te" x "Du zi xian" combination: The thousand grain weight of "Ai jiao nan te" was 23.38 grams, that of "Du zi xian" was 21.55 grams and that of the F_1 plants was 23.81 grams, manifested as a superior dominant characteristic. The thousand grain weight of F_2 plants was 26.06 grams, showing as even greater superiority over the parents. Its distribution approached a normal curve.

"Ai zi zhan" x "Tuo tuo pu" combination: The thousand grain weight of "Ai zi zhan" was 22.91 grams, that of "Tuo tuo pu" was 19.4 grams, that of F_1 plants was 24.67 grams, and that of F_2 plants was 23.7 grams. The thousand grain weight of F_1 and F_2 plants all showed superior dominant characteristic. The distribution characteristic was the same as above.

"Di jiao wu jian" x "Ye hua zhan" combination: The thousand grain weight of "Di jiao wu jian" was 24.00 grams, that of "Ye hua zhan" was 25.79 grams, that of the F_1 plants was 23.06 grams, between those of the parents, and the thousand grain weight of F_2 plants was 27.92 grams. Its distribution frequency pattern was the same as the above.

"Di jiao wu jian" x "Ai zhong shui tian gu" combination: The thousand grain weight of "Ai zhong shui tian gu" was 19.5 grams, that of the F_1 plants was 21.48 grams and that of the F_2 plants was 23.42 grams. The distribution of this characteristic was the same as the above.

"Fu bao ai" x "Du zi xian" combination: The thousand grain weight of "Fu bao ai" was 20.4 grams, that of "Du zi xian" was 21.55 grams and that of the F_1 plants was 21.21 grams. The thousand grain weight of the tall stemmed group of F_2 plants was 23.96 grams, that of the short stemmed group was 23.79 grams. The distribution of this characteristic was the same as the above. The thousand grain weights of the F_2 plants surpassed those of the parents in manner similar to those of F_2 plants of the "Ai jiao nan te" x "Du zi xian" combination.

The thousand grain weight of the F_2 plants of the combination "Qing xiao jin zao" x "IR24" reached 27.58 grams. The thousand grain weight of the F_2 plants of the combination "Hong mei zao" x "IR24" reached 27.48 grams, both surpassing those of the parents.

Analysis of the six combinations above showed that variation of the thousand grain weights of the F_2 plants was continuous. The distribution frequency generally was a normal curve or an off normal curve. This indicated that it is a quantitative characteristic controlled by many genes. It is worth pointing out in particular that many plants of the F_2 generation with thousand grain weights surpassing both parents will emerge. These can be further selected.

10. Size of the Boot Leaf

Results of analyzing two hybrid combinations showed that the characteristic size of the boot leaf of the F_2 plants showed a continuous variation and a normal curve distribution. This indicates that this characteristic is also a quantitative characteristic controlled by many genes.

(11) The Degree of Variation of the Major Economic Characteristics of Paddy Rice in the F_2 Generation

According to our measurements, the coefficient of variation (C.V) of each major characteristic of the F_2 plants of different combinations are different. The average C.V values appear in the following ascending order of magnitude: thousand grain weight (8.04%) < length of panicles (8.39%) < growth period (9.65%) < plant height (9.76%) < fruiting percentage of the single plant (13.39%) < size of the boot leaf (21.68%) < total number of grains on each main panicle (24.93%) < highest number of tillers on the single plant (29.03%) < total number of grains on each tiller panicle (33.69%) < number of effective tillers on the single plant (33.77%), as listed in the accompanying table. Summarizing actual experience in breeding, we see that the coefficient of variation of such characteristics as the thousand grain weight, the length of the panicles, the plant height and the growth period during the early period is rather small. The characteristics appear to be easily stabilized, and the effectiveness of selection during the early period is better. The coefficient of variation of such characteristics as the number of tillers and the number of grains on each panicle in the F_2 generation is greater, and it seems to be more effective to select these characteristics in later generations.

Table Coefficient of Variation of Major Economic Characteristics in Paddy
Rice Plants of the F_2 Generation

1) 组合 2) 变异 3) 性状名称	14× 札子粘	16× 紫紫粘	17× 矮花占	18× 矮种水田	2150 19× 小家伙	20 21 高杆群	22 矮杆群	23× IR 24	24× IR 24	25 C.V值
	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次	C.V (%) 次
4) 株 高	4.28 2	20.9 3	19 5	10.45 3	20.1 6	5.39 1	8 2	7.44 5	9.40	9.70
5) 生育期	0.9 1	10.5 2	9 4	13.2 7	13 5	12.4 4	13.18 4	7.23 1	8.5 2	9.6 3
6) 单株最高分蘖	17.4 4	34.3 5	—	25.18 0	27.8 7	—		28.78	37.20 10	29.03 8
7) 单株有效分蘖	28.3 5	28.0 5	30 5	67.11 8	28.70 8	35.7	31.9 7	30.01 14	39.02	33.1 11
8) 穗 长	—	—	—	8.1 1	10.55 1	9.07 3	9.5 3	7.41 2	8.73 3	8.16 2
9) 主穗总粒数		27.3 4	23 4	—	—	20.0	24.5 5	26.04 8	21.35 6	24.03 7
10) 分叉每穗总粒数	—	12.0 7	12 6	—	—	20.3	21.9 6	22.90 7	27.29 7	27.06 10
11) 单株结实率	—	8.6	8	16.08 4	16.80 4	—	—	13.12 5	16.42 5	17.3 5
12) 千粒重	8.24 3	8.5 1	— 1	7 1	11 3	7.5 2	7.2 1	8.66	7.46 1	8.0 1
13) 剑叶大小	—	—	—	20.27 6	17.9 5	—	—	17.95	25.02 8	21.62 6

Key:
1.   Combination
2.   Condition of variation
3.   Name of Characteristics
4.   Plant height
5.   Growth period
6.   Highest number of tillers of the single plant
7.   Number of effective tillers of the single plant
8.   Length of panicles
9.   Total number of grains on the main panicle
10.   Total number of grains on each panicle of the branch leaf
11.   Fruiting percentage of the single plant
12.   Thousand grain weight
13.   Size of the boot leaf
14.   Ai jiao nan te x Du zi xian
15.   Order
16.   Zi zi zhan x Tuo tuo pu
17.   Di jiao wu jian x Ye hua zhan
18.   Di jiao wu jian x Ai zhong shui tian gu
19.   2150 x Xiao jia huo
20.   Fu bao ai x Du zi xian
21.   Tall stemmed group
22.   Short stemmed group
23.   Qing xiao jin zao x IR24
24.   Hong mei zao x IR24
25.   Average C.V value

III. Discussion and Conclusion

The F_2 generation of paddy rice is the key to selection. With the help of genealogical analysis, the hereditary patterns of major economic characteristics and certain conditions of genetic composition could be understood. A theoretical basis for the application of ordinary breeding work and exploration of utilizing heterosis of plants of the second generation can be obtained from this understanding.

The results of the experiments showed that after "Ai jiao nan te", "Ai zi zhan" and "Di jiao wu jian" were separately crossed with a tall stemmed parent, analysis of the second generation indicated that the semi-dwarf characteristic utilized in breeding of dwarf varieties of paddy rice was mainly controlled by one recessive gene. But when the plant heights of the plants of the F_2 generation of short stemmed x short stemmed parents are considered, we see that a number of modified genes that affect the plant height in minute variations can still exist in these parents. Analysis of the plant height of F_2 plants of "2150" x "Xiao jia huo" showed that although this recessive gene underwent multiple crossing of many generations, its genetic characteristic remains the same and its inheritance following the same pattern can be foreseen in further utilization. Of course, there may be more than one structure and type of genes controlling plant height. This possibility was seen in the offspring of combinations of "Fu bao ai". But the conclusions reached in the analysis requires further proof.

The other major economic characteristics all show continuous variations in the F_2 generation. The frequency distribution appears as normal curves or off normal curves, indicating that these are quantitative characteristics controlled by many genes. Observed in combination with the hybrids, it can be seen that the mutual relationship of these numerous genes involves cumulative effects and the effect of dominance. The average degree of dominance in the length of panicles, the number of grains and the thousand grain weight in the F_2 generation tends towards greater length, more number of grains and heavier thousand grain weight. But the number of tillers and the number of effective tillers of the F_2 plants are exceptions. It seems that in the course of selecting the above characteristics in paddy rice, emphasis should be on selection among colonies possessing true genetic differences to obtain possibly better results. Understanding the distribution pattern of these characteristics in the F_2 generation has a definite significance in guiding breeding work.

According to the results of the experiments, the average coefficient of variation of such characteristics as the thousand grain weight, length of panicles, growth period and plant height is rather low. In view of previous reports, the heritability of these characteristics is stronger, therefore they should be selected on a strict basis during the early stages. The coefficient of variation of the other characteristics indicates the coefficient of variation of the total number of grains and the number of tillers of each hybrid combination is large. Thus, selecting such characteristics by the genealogical method is not comprehensive enough. It is best to consider combining the

genealogical method (selection of the characteristics in higher generations, concentrating on strict selection of characteristics of strong heritability) and the group method (selection of the characteristics in later generations, concentrating on the selection of characteristics with weak heritability among superior lines).

Further studies are required to solve the problem of separation of certain characteristics in the F_2 generation and to explore the question concerning the existence of superiority in the F_2 generation. This experiment indicates that among the three major elements constituting yield of F_2 plants, the thousand grain weight can still manifest dominance or superior dominance. Length of panicles and the number of grains on the panicles are characteristics that show superior dominance, dominance, manifestations between those of the two parents and negative superior dominance in the F_2 generation. In the case of the first two manifestations of superior dominance and dominance, it is possible to obtain a certain degree of heterosis for the number of grains on the panicles among F_2 plants. In addition, the length of panicles may also manifest superiority among F_2 plants of some combinations. If the fruiting percentage of the parents is high, the fruiting percentage of F_2 plants will also be better. Among the economic characteristics that affect yield, superiority in the number of tillers of F_1 plants drops rather visibly in the F_2 generation of a majority of combinations. But in certain short stemmed x short stemmed combinations, the tillering ability of F_2 plants may possibly be between that of the two parents, or may be close to the tillering ability of the parent possessing a greater tillering ability. Therefore, an appropriate tillering ability may be maintained in the F_2 plants. The problem concerning the visible reduction in the tillering ability and the number of effective panicles of the plants of the F_2 generation in the majority of combinations can be solved by the technique of planting more plants in cultivation.

Some questions concerning separation of the growth period in the F_2 generation have also been answered by these studies. If the growth periods of the two parents are close, then 60 percent of the plants of the F_2 generation can reach their heading times within a margin of 5 days. Therefore, if some of the experience of the masses in selecting and retaining seeds and eliminating impure seeds of the F_1 plants are taken into consideration, then utilization of F_2 plants of chemically induced sterile combinations is possible. It seems possible that greater superiority of individual characteristics (such as thousand grain weight) of F_2 plants over F_1 plants may have a greater relationship with the climate, and the genetic reasons should be further explored.

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TECHNIQUES FOR HIGH WHEAT YIELDS IN SHANTOU PREFECTURE

Guangzhou GUANDONG NONGYE KEXUE [GUANGDONG AGRICULTURAL SCIENCES] in
Chinese No 5, 20 Sep 79 pp 15-18

[Article from Information Section of Shantou Prefectural Agricultural
Sciences Institute, "Shantou Prefecture's Experiences With High Wheat
Yields and Their Cultivation Techniques"]

[Text] Wheat has long been the principal winter grain crop in Shantou Pre-
fecture. Within the past several years, the area planted to wheat through-
out the prefecture has risen from the more than 186,000 mu in the early
period of Liberation to more than 1.4 million mu, and per mu yields of
between 400 and 500 or even 600 and 700 jin of wheat have come to be typi-
cal in many places. A situation in which the level of per unit yields
has been low is now developing toward one of consistently high yields.
Even though the spring of 1978 and 1979 had long periods of dark, rainy
days such as rarely happen, and despite the high relative humidity, many
units still harvested consistently high yields. In Chaoan County, for ex-
ample, the number of communes getting more than 300 jin in 1978 rose from
2 in 1977 to 6. The number of brigades getting between 400 and 500 jin
rose from 8 in 1977 to 22 in 1978, and there were 36 production teams with
yields in excess of 500 jin, with two production teams that harvested in
excess of 600 jin.

Experience shows that through diligent mastery of the laws governing high
wheat yields, by bearing in mind the climate and the characteristics of
wheat growth, and by striving to improve farming techniques, it is entirely
possible to top high yields with even higher yields.

1. Making Rational Arrangements For Each Stage of Wheat Growth On the Ba-
sis of Climatic Characteristics

On the basis of surveys of high yielding fields and phenological observa-
tions of wheat conducted by the Shantou Meterology Station, cultivation
of wheat during winter and spring in our region shows strong sensitivity
to temperature. Temperature sensitivity is particularly noticeable during
the period from the sowing of seeds through the heading stage. When the

seed is planted in November, there is a need for fairly stable accumulated temperature throughout the growing period. Early maturing varieties such as "Fumai No. 7" [Fumai No 7] and "Hongmang 22 [Hungmang 22]" require accumulated temperatures around 1600-1700°C throughout the growing period. Mid- to late-maturing varieties such as "Hongman [Hungman]", "Baimang [Paimang]", and "Jinmai 52 [Chinmai 52]" require accumulated temperatures around 1800-1900°C throughout the growing period. However, the growing period is determined by differences in the daily average temperatures and varying lengths of days. Generally speaking, 8 days will be required between sowing of seeds and sprouting when daily temperatures average about 17.0°C; 25 days will be required from the sowing of seeds to tillering when daily temperatures average 17.8°C. When daily temperatures average around 15°C, between 63 and 65 days will be required from the sowing of seed until heading; when daily temperatures average 1.39°C 59 days will be required from heading until full maturity.

Observations show that for our area average temperatures of between 14 and 17°C are most advantageous for the tillering of wheat. Once heading has occurred the amount of sunlight becomes very important; when there is a lot of sunlight between the milk-ripe stage and the yellow-ripe stage, the per thousand weight of grain increases pronouncedly. Contrariwise, when dreary, damp, and rainy days are numerous between the time of heading and the time of maturation, both the fruiting rate and the per thousand weight of grains is seriously affected.

Our prefecture faces the sea with mountains at its back, and the Tropic of Cancer runs right through the middle of it; consequently, late spring is characterized by warm, foggy weather ahead of a front. Too many foggy and rainy days are bad for wheat growth, as was the case in 1978 when 153.3 millimeters more rain than usual fell during March and the number of rainy days increased by 12 causing a decline of from 5 to 7 grams over normal years in the per thousand weight of grain in some wheat fields. From this may be seen that every effort should be made to plan to take advantage of climatic conditions during the various stages in the growth of wheat. This is an important measure for obtaining consistently high yields. Investigation shows that through adjustments in the planting times of the late crop in our prefecture during the past few years, it has been possible to maintain consistently high yields from the late crop and get early ripening when planting mid- and late-ripening varieties between early and mid-November, and early ripening varieties around 22 November. In this way it is possible to make full use of the rather warm conditions of early winter to promote sprouting and tillering, early growth and rapid development, and to advance the growth period. This will guarantee that the heading and flowering period will occur when daily average temperatures are fairly low in the sunny weather of early and mid-January, with the ripening period falling at the end of March or in early April so as to avoid the bad weather that comes after April when high temperatures force ripening. Thus we can manage to get three crops a year with consistently high yields.

2. Reasonable Control Over Colony Formation

Wheat yields are decided by the coordinated development of the number of spikes, the number of grains, and the weight of the grains. Therefore, cultivation techniques that create a rational dynamic formation of colonies is a key link in consistently high wheat yields.

Both experiments and practice in production during the past several years show that the number of wheat spikes is dependent on the number of shoots, and that the number of grains and weight of grains are affected by their individual rates of growth. In our prefecture a universal situation exists in which, as the basic number of shoots increase, tillering increases and the spike formation rate declines. However a goodly number of effective spikes result in the end. The number of grains and the weight of the grains increases with the number of spikes, and as the number of grains decreases the per thousand weight of grains increases.

It may be seen from this that in our prefecture the high yields of wheat is derived mostly from the main spike, and the trick is to get the largest spike possible in order to increase the grain weight. Investigation shows that in order to get per mu yields in excess of 500 to 600 jin, it is necessary to insure between 200 and 250 thousand spikes per mu with between 30 and 35 grains in each spike for a thousand grain weight in excess of 40 grams. The experience of the masses in getting such spike and grain formation is as follows:

(1) When early winter temperatures are fairly high and sunlight ample so that young plants will grow and tiller, and given favorable conditions in fertilizer and availability of water, plus restraint in sowing only the proper number of seeds so that there won't be too many seedlings at the outset, some of the tillers will result in heading and there will be numerous spikes that are large and in which the grains are heavy. An example is the Chaoan County Agricultural Sciences Institute, which in 1976 grew 147,200 basic seedlings of Baimangxuan 71 [Paimanghsuan 71] per mu to get a maximum 452,600 tillers, which through intensive fertilizer and water management resulted in 224,200 effective spikes for an average per mu yield of 619.2 jin.

(2) Given that the characteristics of different varieties require sowing of different amounts of seed and that, generally, early maturing varieties will have a short vegetative growth period, the amount of seeds sown should be appropriately increased, though seedlings should not exceed 220,000. With mid- and late-maturing varieties, inasmuch as most have quite strong tillering strength, large spikes and numerous grains, fewer seeds should be sown than for early maturing varieties so as to allow the full development of potential for large spike and heavy grains, but insure that there are no fewer than 180,000 seedlings. An example is the Neipan Brigade of Dongfeng Commune in Chaoan County where the winter variety of wheat, "Jinmai 2148" [Chinmai 2148] was selected. It is a mid- to late-maturing variety with

strong tillering that produces 200,000 basic young plants with a maximum 410,000 young plants and a final 185,000 effective spikes on average. Each spike averages 42.8 grains for which the per thousand weight is 46.35 grams giving yields averaging 566 jin per mu.

(3) Fields that are sown late require appropriate increases in the number of seeds sown in comparison with those sown early, and spikes on the main stems are relied on for high yields. In the case of a winter variety sown in 1977 by the Nanshe Brigade of the Waisha Commune in Chenghai County, the wheat was sown on 22 November because late rice was harvested late from the fields. The amount sown was increased to 28 jin per mu to assure at least 220,000 seedlings, a maximum 580,000 tillers, and a final 270,000 effective spikes. Though the number of grains per spike declined to 25, the per thousand weight was 42 grams. Thanks to numerous spikes, the average per mu yield was 512 jin.

In view of the practice of getting high yields during the past several years, proper controls to see that the initial number of seedlings is not too high and working to attain a certain number of spikes is of benefit in coordinating the wheat with environmental conditions and the conflict between colonies and individual plants. It is also useful in bolstering plant resistance later on, and is an "advancement" measure that can be handily applied in field management. Investigation has also shown, however, that there is a definite limit to the development of individual wheat plants, that the spike formation rate is usually only 40 to 45 percent, and that the maximum number of spikelets is somewhere between 22 and 25. In figuring the per thousand weight, differences in variety and in year make for big changes as in the case of "Baimang" [Paimang], which showed a difference of about 10 grams for different years. Therefore, it can be figured that for yields of between 500 and 600 jin per mu a reasonable criterion for the closeness of plants is to sow between 22 and 24 jin of seed per mu to get an initial 180 to 200 thousand young plants, with maximum tillering bringing total stems to no more than 400 to 450 thousand. The coefficient of leaf area during the peak tillering and booting stages is held at 4 to 4.5 and 6.5 to 7 respectively.

3. Flexible Use of Measures to "Advance" and "Restrain"

A check of experiments by the agricultural sciences department of our prefecture shows about 25 days from the time of sowing are required for the early-maturing varieties of wheat to entering the double ridge stage, with about 35 days required for mid- and late-maturing varieties. This is the most important stage for determining per unit effective spikes and number of spikelets. Experiments with incremental applications of fertilizer by the Raoping County Agricultural Sciences Institute in 1974 showed that an application of 20 jin of fertilizer when there were 2.5 leaves and an application of 10 jin of fertilizer when there were 4.5 leaves brought an increase of individual young plants within 10 days from 143,500 to 238,100; within 20 days the maximum number reached was 347,500 with 211,500 effective

spikes. This shows that when the vegetative situation is good, timely application of fertilizer provides a good basis for strengthening the young plants, promoting early tillering and numerous tillers so that there are numerous spikes and high yields.

The period from the double ridge stage until the heading stage is the one in which both vegetative growth and reproductive growth is most exuberant. Research shows this period to be between 40 and 45 days after the seedlings first appear in the early-maturing varieties, and from 45 to 50 days after the seedlings first appear in the mid- and late-maturing varieties. At this time there is a polarization in tillering, the stems extend dramatically and the root system grows rapidly. The leaves on early-maturing varieties grow from 3.65 to 7 in number, and on mid- and late-maturing varieties from 5 to 8 or 9 in number. Spikelets, florets, pistils, stamens, and grains of pollen form. It is a crucial time when the number of spikes, number of grains and high yields are decided; it is also the time of high effectiveness for applications of fertilizer and water. Good fertilizer and water conditions have a remarkable bearing on the coordination of growth and development of plant colonies and individual plants alike and in obtaining an equitable formation of plant colonies, in increasing the spike formation rate, in increasing the number of spikelets and the number of florets on each spike and in decreasing deterioration in the number of spikelets and florets. For instance, on 10 hilly high yielding wheat fields at the Neipan Brigade in Dongfeng Commune in Chaoan County, applications of between 15 and 18 jin per mu of fertilizer to promote jointing were made between 30 and 45 days after sowing (at the 5 to 8 leaves stage). Three days after redness appeared on the young wheat seedlings when the boot leaves first began to appear, an application of 9 jin of fertilizer per mu was made as a side dressing. The results of use on the "Baimang" [Paimang] variety were an increase of 10 percent in the number of spikes per mu over 1976 when no fertilizer was applied, and an increase of 34.6 percent in the number of grains per spike. In experiments conducted by the Prefectural Agricultural Sciences Institute in 1974 using soils of identical quality (1.239 percent organic matter and 0.0858 percent nitrogen) and of identical fertility (40 dan of human and animal manure in water, 300 jin of manure of varied origins and constitutents, 30 jin of phosphate, and 10 jin of ammonium sulfate per mu), the addition of 2. 7 jin of chemical fertilizer per mu during the double ridge stage produces   00 additional spikes per mu than was the case when only 10 jin of fertilizer per mu was added. The number of grains per spike increased by 1.3 with a per thousand grain weight increase of 1.1 grams. But, under conditions of high yield cultivation with high levels of fertilizer and water being added, if control was not properly exercised during this phase, plant colonies can frequently be overly large with adverse effects for individual plant development, thus inhibiting high yields. In 1977 at the Chaoan County Agricultural Sciences Institute, for instance, where "continuous greeness" was maintained, the rate of sterility rose from 6.5 percent to 16.4 percent over 1976 for the same variety. This shows that from the double ridge stage to the heading stage, the applications of fertilizer and water are most important for growth, but applications in such a way as to promote and yet restrain growth.

The period from the heading of the wheat until its ripening, which is generally 60 days for early-maturing varieties and 65 days for mid- and late maturing varieties, amounts to between 50 and 52 percent of the total growth period. Though the number of grains per spike are already fixed by this time, nevertheless good nutrient conditions and external environment are beneficial to the development of roots and to the maintenance of leaves, particularly to the lifespan of apical leaf elongation, to the protection of the grains, to the increase of grain weight, and to the prevention of a degeneration in the already formed pollen grains with consequent reduction in the number of grains. Consequently, after heading has occurred, a further application of phosphate and potassium supplemented with nitrogenous fertilizer is most important for providing resistance to crop failure and in increasing the weight of grains. In the case of the Dashang Brigade of the Simapu Commune in Chaoyang County during 1974, for example, a high-yield field of "Bodamu" [Potamu] was grown. Following heading, a supplementary amount of 16 jin per mu of chemical fertilizer was applied that increased the per thousand weight of grains by 2.8 grams over the fields to which no supplemental fertilizer had been applied.

Mastery of the laws governing the growth and development of wheat, a clear understanding of requirements for fertilizer at various stages, and timely measures to promote or restrain growth are the best assurances for high crop yields in wheat. Using the principles of fertilizer applications for paddy rice, every place during recent years has applied a sufficient amount of basic fertilizer and then gone on to an early application of fertilizer for the initial wheat shoots, followed by a tillering fertilizer just before the fourth leaf [stage], a heavy application of fertilizer at the jointing stage, and then appropriate applications to strengthen spikes and grains. Figuring overall amounts of fertilizer applied to high yield fields, more than 20 jin of pure nitrogen will have to be applied to produce per mu yields of 500 jin. In an actual situation such as the 604 jin per mu yields obtained in 1977 by the Chaoan County Agricultural Sciences Institue, methods of fertilizer application were as follows:

(1) Early Stage (from appearance of seedlings to double ridge stage) to Promote Tillering and Strengthen Seedlings

Presuming that there has been a sufficient application of basic fertilizer, when the young shoot has grown to the point where it has produced two leaves on a single stem and is between 4 and 5 days away from tillering. apply 25 jin of ammonia water per mu, 30 dan of liquid human or animal excrement (if the quality of the liquid excrement is poor, between 10 and 15 jin of ammonium chloride should be added to it), and 15 jin of calcium superphosphate. When there are four leaves on a single stem, 7 dan of pond mud should be applied plus 35 din of ammonia water (add up to 21 dan of water). Since the weather is dry during November and December, watering must be done after the seeds have been sown. Also, during the period of tillering irrigate once or twice at the time fertilizer is applied. When there are two leaves on one stem, and again when there are four leaves on

one stem, the tillering fertilizer should be combined with one rolling of the wheat each time.

(2) Mid-Period (Double Ridge Stage to Heading Stage) With Improvement in Rational Colony Formation, Making Sure of Heading and Maintenance of Grains

Around the time of jointing, when the red color begins to fade from the leaves and the coefficient of the area of largest leaves is no more than 7, between 10 and 12 jin of potassium chloride should be applied per mu, as well as between 8 and 10 jin per mu of ammonium sulfate as a embryo strengthening fertilizer. When the boot leaves have completely formed and droop with their color turning light in tone, between 5 and 6 jin of urea should be applied to assure good heading. Once the leaves curl downward and their color becomes dark green, fertilizer applications should be slowed, decreased, or stopped. Watering with "running water" should be combined with one application of a embryo and spike fertilizer.

(3) Late period (from Heading to Harvest) With Lengthening of the Life Span of Apical Leaves and Increasing the Weight of Grains

In addition to maintaining the proper moisture in the fields and getting rid of accumulated water, once heading has occurred, 15 jin per mu of calcium superphosphate should be applied together with between 8 and 10 jin of potassium chloride. In fields where individual leaves begin to fade to a red color and during when the grain is in the mid- and later milk stages, make supplementary applications of from 3 to 5 jin of urea.

4.   Resistance to Disease and Lodging, and Insuring a Bumper Harvest

Apart from rust as a factor affecting increases in wheat yields, [because of] the harm done by wheat scab since 1973, it has become a major plant disease threatening wheat production in our prefecture. Investigation has shown the following to be the principal measures taken in various areas to prevent wheat scab:

1.   Choice of varieties resistant to the disease. Evaluation of production and results of experiments show "Hongmang" [Hungmang], "Baimang" [Paimang], and "Jinmai 1082" [Chinmai 1082] to be resistant to wheat scab.

2.   Advancing the time of planting to make the flowering and milk stages of the grain avoid hot and rainy weather. Wheat scab is most prevalent during the time when the wheat is flowering. If this period occurs during a time of hot and rainy weather, the outbreak is serious. Thus the number of rainy days and the amount of rainfall are decisive factors. In the case of Puning County's 1976 spring harvest of wheat, all seeding had been done during the early and mid-part of the previous November with the flowering and milk stages occuring during the later part of January and early February. At this time temperatures averaged 13°C with a relative humidity

of 77.6 percent, an average of 3 rainy days, and a rainfall of from 1 to 45 millimeters. Consequently the incidence of disease outbreak and the degree of its seriousness was under 0.1 percent. On the other hand, seed sown during the latter part of November had its flowering and milk stages during mid- and late February. At this time temperatures averaged 16.4°C, relative humidity was 86 percent, rainy days numbered 12, and rainfall amounted to 20.15 millimeters. Incidence of disease reached between 2.83 and 17.83 percent and the degree of seriousness was from 1.13 to 10.95 percent.

3. Control of moisture in fields. Wherever depressions accumulate water or where the underground water table is high, the disease is quite serious; when conditions are the opposite, the disease is light. By digging "three ditches" and building drainage ditches shaped like the character 丰 , all areas have been able, in recent years, to increase the land utilization rate and improve the porosity of the fields bringing about a decline in the wetness of the fields and reducing the occurence of disease.

4. Use of chemical controls. On the basis of experiments conducted by the Prefectural Agricultural Sciences Institute during 1975 and 1976, successive spraying at the time of flowering and during full flowering with 50 percent thiophanate methyl, 50 percent benpianmizuo [0058 7478 4717 8143], 50 percent dakenir [2092 0344 1441 1422], jinggang meisu [0064 1511 7199 4790], Colsul and lime sulphur is quite effective in the control of wheat scab. Control effectiveness for the thiophanate is better than 94 percent, and for the benpianmizuo and the dakenir it is from 88.87 to 94.23 percent and 66.15 to 82.49 percent respectively. For the Jinggagmeisu, the Colsul, and the lime sulphur, it is 39.39 percent, 39.92 percent, and 37.35 percent, respectively, and these are effective against wheat rust at the same time.

The strengthening of wheat resistance to lodging is another key to high yields. Investigations show that lodging in wheat causes a reduction in yields greater and more irreparable than those caused by diseases and pests, and is the leading "disorder" preventing high wheat yields. The masses say that "lodged wheat is a bundle of straw."

In addition to physiological reasons, lodging in wheat results principally from overcrowding of plant clusters during the early period of growth so that spindly stems are produced. Unsuitable regulation of the seedling and jointing stages during the mid-period of growth will produce an over extention of the first and second nodes. In some wheat fields where embryo and spike fertilizers have been overly rich in nitrogen "the tips of the stalks become heavy while the base remains slender." In recent years a lot of experience has been gained in getting high yields without lodging by careful preparation of the fields, improved quality of seeds, use of drills in planting, and increased use of organic fertilizer. When the plants have produced 2.5 leaves and again when they have produced 4.5 leaves, they should be rolled (pressed) to strengthen the young seedlings

so that the stems will become thicker, the leaves wider and thicker, and the root systems developed. When growth is too vigorous during the seedling stage, control of water during mid-period as well as control of fertilizer to delay jointing, rational use of spike and grain fertilizer and especially such cultivation measures as the careful application of fertilizer to strengthen grain formation have all been very effective.

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BRIEFS

NEW PRAWN DRAGNETS DESIGNED--Following more than a year of research, technicians at the Shandong Provincial Oceanic Aquatic Products Institute have successfully designed and manufactured a new type of dragnet for catching prawns without catching small young fish. The new dragnets were designed according to the principle that when fish are frightened, they try to escape by diving downward and then jumping upward, and that when prawns are frightened, they jump and come to the surface. Experiments have shown that the new nets can increase the catch of prawns by 14 percent and reduce the damage to young fish by 69 percent as compared with the old type of dragnets used in the past. [Beijing GUANGMING RIBAO in Chinese 25 Feb 80 p 2]

BIOLOGICAL CONTROL OF INSECT PESTS--A 1979 provincial-wide survey on the resources and development of natural enemies of crop insect pests showed there are 563 species of such natural enemies and 25 species of microbial ones in Shandong. In 1979, these natural enemies were used to control insect pests on more than 27 million mu of farmland with "relatively good" results. By using natural enemies to control wheat aphis on 1.57 million mu, Changwei Prefecture managed to reduce the use of pesticides by 4.71 million jin, thus saving nearly 1 million yuan. [Beijing GUANGMING RIBAO in Chinese 26 Feb 80 p 2]

CSO: 4007

BRIEFS

ANCIENT FORESTS SURVEYED--Recent overhead and ground surveys showed that the Tarim Basin of Xinjiang has 280,000 hectares of Populus diversifolia forests, which are natural forests of an ancient variety of poplar trees. These forests, located mainly in the valleys of Tarim, Yarkant and Hotan rivers, formed a "long green corridor" preventing the Taklimakan Desert from spreading. The present total acreage of these forests, however, is 45 percent smaller than in 1958 as the result of water shortage and indiscriminate logging. [Beijing GUANGMING RIBAO in Chinese 25 Feb 80 p 1]

CSO: 4007

MANAGEMENT OF AGRICULTURAL RESEARCH REFORMED

Beijing GUANGMING RIBAO in Chinese 25 Feb 80 p 2

[Report by Du Yali, GUANGMING correspondent: "Zhejiang Reforms Its
Management System for Agricultural Scientific Research"]

[Text] How can we make the management system for agricultural scien-
tific research meet the need to modernize agriculture? The reform of
the management system for agricultural scientific research in Zhejiang
Province last year showed that individualism must be smashed and the
"small, but complete" concept must be changed so that the limited man-
power, material and funds may be used on the most important tasks to
bring about a broad and far-reaching advancement in agricultural
scientific research.

There are now 91 provincial, prefectural and county level agricultural
(or animal husbandry) scientific research institutes in Zhejiang
Province, and most of them were established in accordance with the
administrative zoning after 1960. In the past decade, these agricul-
tural scientific research organizations have played a role in raising
grain production and in developing industrial crops, including cotton,
hemp, mulberry trees for silkworms and citrus fruits throughout the
province. However, due to the lack of a unified leadership in the
management system and of a unified plan and rational division of labor
in research projects, there was no communication among these institutes.
This caused numerous duplications in research projects, leading to
decentralization and waste of manpower, material and funds, and adversely
affecting the achievement of more results at an early date. To cope with
these confused conditions, agricultural scientists and technicians
throughout the province urgently demanded a reform in the management
system for scientific research. Consequently, the provincial CCP com-
mittee and the provincial Scientific Commission of Zhejiang began in
April last year to readjust the agricultural scientific research organi-
zations at the provincial and prefectural levels and clearly designated
the provincial Academy of Agricultural Science of Zhejiang as the compre-
hensive agricultural research center for the entire province, with
responsibility for all the agricultural research work in the province.

The prefectural agricultural research institutes adopted a two-level management system under which the provincial Academy of Agricultural Science played a key role in exercising leadership, while the prefectures played a secondary role; that is, the provincial Academy of Agricultural Science was responsible for setting a course for conducting research work and for staffing, funds and capital construction investments, while the prefectures were responsible for party work and the day-to-day administrative and managerial matters. This type of reform facilitates the unified planning of research tasks of various institutes and creates a favorable condition for the future establishment of agricultural research organizations according to agricultural zoning.

While actively reforming the management system for agricultural scientific research, the provincial Academy of Agricultural Science of Zhejiang has also formulated an overall plan for agricultural development in the entire province and for the major research tasks of the agricultural research institutes at various levels according to the principle of sharing work and cooperating with one another, and according to the degree of importance. Each year in the past, the research institutes of various localities assigned large numbers of personnel and used large areas of land to conduct research on the cultivation of rice seeds of the Xian [Indica] and Keng [Japonica] varieties. Now it has been initially decided that the source [procurement] of strains is the sole responsibility of the provincial Academy of Agricultural Science and that the tasks of selecting and cultivating seeds are to be divided among various agricultural regions according to the regional characteristics, and among the research institutes according to their special skills. To counter the low and unstable output of large acreages of late rice in this province, the provincial Academy of Agricultural Science has demanded that this be considered a major research task for the entire province and that a joint effort be launched to attack this problem. As the result of various measures, the phenomena of duplication in agricultural research projects and of waste in manpower, funds and material have begun to change. The broad masses of agricultural scientists and technicians declared happily that this type of reform was like closing the extended fingers into a fist to transform the agricultural research tasks throughout the province into "a game of chess."

CSO: 4007

HEREDITARY PATTERN OF EARLY MATURITY OF WHEAT STUDIED

Hangzhou ZHEJIANG NONGYE KEXUE [ZHEJIANG AGRICULTURAL SCIENCES] in Chinese
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[Article by Shen Qiuquan [3088 4428 3123] of the Hangzhou Municipal Agricul-
tural Science Research Institute and Zhang Quande [1728 0356 1795] of the
Zhejiang Agricultural University: "Preliminary Study of the Hereditary
Pattern of Early Maturity of Wheat*"]

[Text] To expand the area of triple cropping of wheat in the downstream
rice and wheat regions of Changjiang, solving the seasonal conflict for crop
openings and early maturity has become an important goal in wheat breeding
at present. Along with the breeding of early maturing varieties, a rich
collection of information on the hereditary patterns of early maturity and
selective combination of parents has been accumulated. Yet, past information
is mostly based on using the heading time as the indicator of early maturity.
Observations of the time of maturity which actually manifests early maturity
are still lacking. Thus, we began in 1976 to observe the early maturity of
24 parents and the first generation of 275 hybrids produced by rotational
breeding with these parents as well as the second generation of three hybrids.
This article will take the heading time as the major indicator in combination
with flowering and maturing times, and give a preliminary analysis of the
hereditary pattern of early maturity of the first generation of hybrid wheat
and its offspring.

Material and Method

Twenty-four wheat varieties with different growth periods and of different
ecological types were chosen for this experiment: Mexico 120, Ai gan zao,
908, Anhui No 11, Nan da zao shou No 1, Ning 14526, Yi wu bai ke zao, Yunnan
525, early maturing Jin zhou ai No 21, Bo ta mu, E mai No 6, Taiwan wheat,
Pu shuang No 1, Hubei 975, UP301, Yang mai No 1, Ning 701, You yi wheat,
Nong lin No 10, A zhong No 1, Feng chan No 3, Fan 6, Kiu lan 39, and Beijing

No 8 as parents. The method of rotational breeding was used so that all 24 parents had completely equal chances to form 276 separate and different hybrid combinations (without differentiating between pedigree cross and back cross) so that the results at time of analysis were evenly scattered and comprehensively comparable.

In autumn of 1975, the 24 parents for rotational breeding and 275 first generation hybrid seeds were sown in Hangzhou. Each was planted in three rows separated by 8 cun between rows. The plants were 3 cun apart and 10 plants were planted in each row. Ten plants were fixed for each group and parent. The heading time and flowering time of each plant was recorded and the plants were tagged. The maturity time was noted according to the numerical designation of the lines.

The results of the experiment were subjected to statistical analysis. The method of calculation of the coupling ability is:

General coupling ability = the average value of the parent and the hybrid of that parent - average value of all combinations of hybrids in the experiment.

Special coupling ability = the average value of that combination - (average value of the entire experiment + general coupling ability of parent A + the general coupling ability of parent B).

According to calculations of the above formulas when the coupling ability of the growth period of the parent is negative, it indicates that the parent possesses a coupling ability of early tendency. The greater the negative value the stronger the coupling strength of early tendency.

Material of the second generation of the three hybrids consisted of four varieties of different characteristics. They were: early maturing and early maturing vernal Jin zhou ai No 21; early maturing and semi-winter 908; late maturing vernal Yang mai No 1 and winter Nong lin No 10. The three combinations were: early maturing Jin zhou ai No 21 x 908; early maturing Jin zhou ai No 21 x Yang mai No 1 and early maturing Jin zhou ai No 21 x Nong lin No 10.

Single seeds of the second generation hybrids were sown. Single plants were tagged and the heading times recorded. Distribution of the heading times of the F_2 plants was statistically calculated.

Results of the Experiment

1. Manifestation of Early Maturity of First Generation Hybrids:

Past studies mostly used heading time as the indicator of early maturity, while actually after heading, flowering may occur early or late and filling may be fast or slow. In order to make an overall observation of the manifestation of early maturity of the first generation hybrids in this experiment, detailed records of the heading times were kept and at the same time

the flowering times and maturity times were recorded. The heading times, flowering times and maturity times of 275 first generation hybrids classified statistically according to the types of manifestation of early maturity are listed in Table 1.

Table 1 shows that whether it is the heading time, the flowering time or the maturity time, all types of manifestations emerge from different parental combinations. These types are: earlier than the early maturity parent, maturing at the same time as the early maturing parent, maturing earlier than the average of both parents, maturing later than the average of both parents, maturing at the same time as the late maturing parent, and maturing later than the late maturing parent.

Table 1 Manifestations of Early Maturity of 275 First Generation Hybrids

1)生育期	2)早熟性的表现类型	3)组 合 数	4)占全部组合%
5)抽穗期	超 早 亲 8)	59	21
	早于双亲平均值 9)	116	42
	迟于双亲平均值 10)	70	26
	超 晚 亲 11)	30	11
6)开花期	超 早 亲	133	48
	早于双亲平均值	51	19
	迟于双亲平均值	73	27
	超 晚 亲	18	6
7)成熟期	超 早 亲	52	19
	早于双亲平均值	37	13
	迟于双亲平均值	105	38
	超 晚 亲	81	30

12) 注：同早亲和同晚亲类型的数值极少，已分别归入
超早亲和超晚亲类型中。

Key:
1. Growth period
2. Types of manifestation of early maturity
3. Number of combinations
4. Percentage of total combinations %
5. Heading time
6. Flowering time
7. Maturity time
8. Earlier than the early maturing parent
9. Earlier than average of both parents
10. Later than average of both parents
11. Later than the late maturing parent
12. Remark: The number of plants having the same maturity times as the early maturing parent or the late maturing parent is very small and they have been included in the types maturing earlier than the early maturing parent and maturing later than the late maturing parent.

The heading time of 175 of the 275 hybrids showed an early maturing tendency, or 63 percent. Of these, 59 hybrids matured earlier than their parents or matured at the same time as the early maturing parent, or 21 percent. There were 116 hybrids that matured earlier than the average of both parents, or 42 percent. In addition, there were 70 hybrids that matured later than the average of both parents, or 26 percent. There were only 30 hybrids that matured at the same time as the late maturing parent or later than the late maturing parent, or 11 percent.

The flowering time of 184 of the total showed an early flowering tendency, or 67 percent. Of these, 133 hybrids flowered earlier than the early flowering parent or flowered at the same time as the early flowering parent, or 48 percent. There were 51 hybrids that flowered earlier than the average of both parents, or 19 percent. There were 91 hybrids that manifested a tendency to flower at the same time as the late flowering parent, or 33 percent.

As regards maturing times, the first generation hybrids of 52 combinations matured earlier than the parents or matured at the same time as the early maturing parent. The first generation hybrids of 37 combinations matured earlier than the average of both parents. These two groups add up to only 89 combinations, or 32 percent of the total, while the hybrid first generation of 186 combinations showed a late maturing tendency, or 68 percent.

It can be seen from the above results that both the heading time and flowering time of the first generation hybrids show an obvious early tendency, and the flowering time has the strongest tendency to occur early. The flowering time of the first generation hybrids of nearly half of the combinations flowered at the same time or earlier than the early flowering parent. The maturity time of the first generation hybrids of about one-third of the combinations tended to occur early, but those first generation hybrids of most combinations showed a tendency to mature late. This is because the first generation hybrids possess a superior strong vitality. This has extended the filling time, raised the thousand grain weight, and thus maturity is correspondingly delayed.

Different growth periods of the parents can affect the manifestation of early maturity of the first generation hybrids. We classified the 24 parents of rotational breeding into early, intermediate and late types according to the time of heading of each. The Zhe 908 was used as the standard early heading parent and Ning 701 was used as the standard late heading parent. Those that headed earlier than Zhe 908 were classified as early heading parents, those heading later than Ning 701 were classified as late heading parents, and those that headed between the two were classified as intermediate maturing parents. Then the 175 combinations were classified into six types of combinations of early x early, early x intermediate, early x late, intermediate x intermediate, intermediate x late and late x late. The statistically calculated heading times are listed in Table 2.

Table 2 The Effect of Different Types of Combinations Upon the Heading Times
of First Generation Hybrids

1) 组合类型	2) 组合数	3) 超早亲和同早亲		6) 早于双亲平均值		7) 迟于双亲平均值		8) 超晚亲和同晚亲	
		4) 组合数	5) 占组合数%	组合数	占组合数%	组合数	占组合数%	组合数	占组合数%
9) 早×早	55	18	33	10	18	14	25	13	24
10) 早×中	66	10	15	24	36	21	32	11	17
11) 早×迟	77	3	4	55	71	19	25	0	0
12) 中×中	15	9	60	0	0	2	13	4	27
13) 中×迟	41	7	17	21	51	12	29	1	3
14) 迟×迟	21	12	57	6	28	2	10	1	5
15) 合计	275	59	21	116	42	70	26	30	11

Key:
1. Types of combination
2. Number of combinations
3. Earlier or at the same time as the early parent
4. Number of combinations
5. Percentage of the number of combinations %
6. Earlier than the average of both parents
7. Later than the average of both parents
8. Later or at the same time as the late parent
9. Early x early
10. Early x intermediate
11. Early x late
12. Intermediate x intermediate
13. Intermediate x late
14. Late x late
15. Total

It can be seen from Table 2 that the phenomena of heading earlier than the
early heading parent, heading at the same time as the early heading parent,
heading later than the late heading parent and heading at the same time as
the late heading parent more easily occur among the types of combinations of
parents with similar heading times. Since the heading time of the first gener-
ation hybrids has the characteristic of tending to be early, the proportion of
heading earlier than the early heading parent and of heading at the same time
as the early heading parent is higher. For example, of the 55 early x early
combinations, 18 combinations headed earlier than the early heading parent or
at the same time as the early heading parent, constituting 33 percent of the
total of that type. There were nine such combinations in the 15 intermediate
x intermediate type of combinations, or 60 percent. There were 12 such combi-
nations in the 21 late x late type of combinations, or 57 percent. Of the
total of 91 combinations of these three types of combinations, 39 combinations
headed earlier than the early heading parent or at the same time as the early
heading parent, or 43 percent. There were 18 combinations that headed later
than the late heading parent or at the same time as the late heading parent,
or 20 percent.

As the difference in the heading times of the parents increases, i.e., when one parent heads early and one late, the phenomena of heading earlier than the early heading parent, heading at the same time as the early heading parent, heading later than the late heading parent, and heading at the same time as the late heading parent diminish. The combinations of the type that tends to head early still constitute over half the number, and a great majority of combinations that tend to head early is found to be distributed below the average of both parents. For example, among the 66 early x early combinations, there were 10 combinations that headed earlier than the early heading parent or at the same time as the early heading parent, or 15 percent. Among the 41 intermediate x late combinations, there were 7, or 17 percent. Among the 77 early x late combinations there were only 3, or 4 percent. Among all of the 184 combinations of these three types of combinations, there were 20 combinations that headed earlier than the early heading parent or at the same time as the early heading parent, or 11 percent. There were 12 combinations that headed later than the late heading parent or at the same time as the late heading parent, or 7 percent. There were 100 combinations that headed earlier than the average of the parents, or 54 percent. There were 52 combinations that headed later than the average of the parents, or 28 percent.

2. The Relationship Between the Early Maturity of the Parents and the Early Maturity of the First Generation Hybrids:

The method of rotational breeding was used in this experiment so that the parents participating in the experiment all had a completely equal chance to form various different hybrid combinations. Thus the relationship between the characteristics of the parents and the characteristics of the hybrid first generation could be more efficiently studied. The heading times, flowering times and maturity times of the parents and their corresponding hybrids are listed in Table 3.

It can be seen from Table 3 that a close relationship exists between the early maturing characteristic of the parents and the early maturing characteristic of the hybrids. To describe the degree of closeness and the direction of the relationship between the early maturity of the parents and the early maturity of the hybrids, the average values of the heading times, flowering times and maturity times of the parents and those of the hybrids of these parents were subjected to correlative and regressive analysis. The results are listed in Table 4.

Table 3 Heading times, flowering times, maturity times of the parents (x) and their corresponding hybrids (y)

1) 组 号	2)抽 穗 期		3)开 花 期		4)成 熟 期	
	x	y	x	y	x	y
1	23.0	21.9	25.0	25.3	53.0	54.5
2	17.0	20.2	25.0	25.6	53.0	54.8
3	22.0	21.8	26.0	26.0	55.0	54.5
4	21.8	22.1	26.0	25.9	55.0	55.3
5	18.4	20.2	25.0	25.4	52.0	54.7
6	20.7	21.1	25.0	25.6	54.0	54.9
7	21.6	21.6	26.0	25.8	53.0	54.0
8	20.4	21.2	25.0	25.5	54.0	55.7
9	15.7	21.9	21.0	25.7	51.0	55.7
10	22.6	22.3	26.0	26.0	58.0	56.9
11	22.8	22.3	27.0	26.0	55.0	55.8
12	21.4	21.7	26.0	26.0	53.0	55.5
13	19.3	21.1	25.0	25.9	54.0	56.0
14	24.1	22.5	26.0	26.1	57.0	56.5
15	26.3	23.6	27.0	26.2	54.0	56.3
16	28.8	24.8	29.0	27.1	58.0	57.4
17	24.3	22.9	27.0	26.4	57.0	57.0
18	25.4	23.3	27.0	26.4	57.0	57.3
19	28.6	23.9	29.0	26.5	59.0	56.8
20	23.3	23.0	26.0	27.0	54.0	56.5
21	23.0	23.1	26.0	26.7	57.0	56.8
22	24.1	22.3	26.0	25.8	57.0	56.0
23	22.2	23.0	27.0	26.4	54.0	56.0
24	20.9	21.4	25.0	26.0	56.0	56.0
5) 总 和	537.7	533.2	623.0	625.50	1320.0	1340.9
6) 平 均	22.40	22.22	25.96	26.06	55.0	55.87

7) 注: 表内数字系从 3 月31日算起的天 数（下同）.

Key:
1. Number
2. Heading time
3. Flowering time
4. Maturity time
5. Total
6. Average
7. Remark: The numbers in the table are the number of days counting from March 31 (the same below).

Table 4 Relationship of Average Early Maturity Between the Parents and the Hybrids of These Parents

Item	Heading time	Flowering time	Maturity time
Correlation coefficient	r = 0.86**	r = 0.64**	r = 0.73**
Regressive equation	y = 15.28 + 0.31x	y = 21.13 + 0.19x	y = 33.72 + 0.33x

The results of correlative analysis showed the average values of the heading times, flowering times and maturity times of the parents and the heading times, flowering times and maturity times of the hybrids of these parents were very visibly positively related. This indicates that the early maturity of the hybrids is determined to a very large degree by the early maturity of the parents. In practice, the choosing and using of ideal early maturing parents are the key to breeding of early maturing varieties and are necessary conditions for forming early maturing hybrid wheat combinations.

The three regressive equations for the heading time, flowering time and maturity time were formulated for regressive analysis: They are: Y = 15.28 + 0.31x, Y = 21.13 + 0.19x, Y = 33.72 + 0.33x. The growth periods of the hybrids were estimated from the growth periods of the parents. Figure 1 shows the line of regression of the heading times of the parents and of their corresponding first generations hybrids. It can be seen from Figure 1 that the distribution of the 24 points generally form a straight line, and the majority of the dots are close to the formulated regressive line Y = 15.28 + 0.31x. This figure further shows a very obvious regressive relationship between the heading times of the parents and the heading times of the hybrids. When the heading time of the parents is late by one day, the heading time of the hybrid is late by approximately 0.31 day. But the use of annual results for estimation by regressive analysis will show a definite error due to climatic variations within the year.
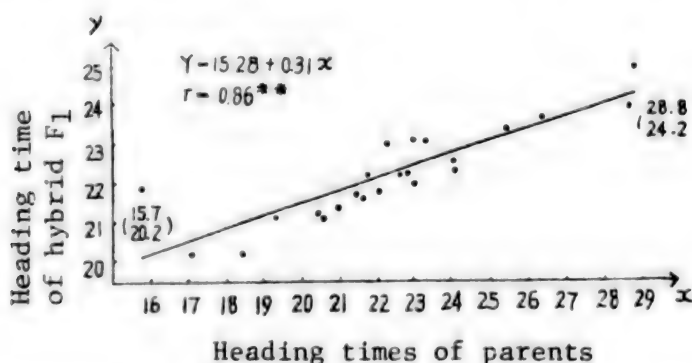

Figure 1 Relationship between the heading times of parents of rotational breeding and the heading times of hybrid F_1

3. Coupling Ability of Early Maturity of Parents:

Early maturity of the parents is closely related to early maturity of the first generation hybrids and their later generations. But the ability of early maturity of different parents to affect the hybrid offspring visibly varies. This involves the question of the coupling ability of early maturing of the parents.

This experiment estimated the general coupling ability and special coupling ability of early maturity of the 24 parents participating in rotational breeding. The results of estimating the general coupling ability is shown in Table 5. The general coupling ability between the heading times, flowering times and maturity times of the parents shows visible differences. Of these differences, the heading times show the greatest difference of 4.6 days, followed by the maturity times of 3.4 days and the flowering times of a smaller difference of 1.8 days.

Parents with early heading times that have a strong coupling ability are in order Nan da zhao shou No 1, Ning 14526, Pu shuang No 1 and Yunnan 525. Their general coupling abilities are respectively -2.0, -1.1, -1.1 and -1.0. Parents with late heading times that have a strong coupling ability are Yang mai No 1 and Nong lin No 10. Their general coupling abilities are respectively 2.6 and 1.7.

Parents with early maturity times that have a strong coupling ability are in order Yi wu bai ke zao, Zhe 908, Mexico 120, Nan da zao shou No 1, Ai gan zao and Ning 14526. Their general coupling abilities are respectively -1.9, -1.4, -1.4, -1.2, -1.1 and -1.0. Parents with late maturity times that have a strong coupling ability are Yang mai No 1 and You yi wheat. Their general coupling abilities are respectively 1.5 and 1.4.

It can be seen from a comparison of the two above that the coupling abilities of early heading times and maturity times of some parents are consistent, while some other parents show inconsistency. This kind of inconsistency reflects the differences between late and early flowering and fast and slow filling after the hybrids head. For example, the coupling abilities of early heading times and flowering times of Yi wu bai ke zao and Zhe 908 are all weak, but the coupling abilities of early maturing times are strong. The reason is because a stronger coupling ability in the speed of filling exists between these two varieties. This can be clearly seen in the field: All first generation hybrids bred from them possess the properties of filling rapidly, good yellowing and decoloring and early maturity. Again for example, the coupling ability of the early heading time of Yunnan 525 is relatively strong, but because the coupling ability of its early flowering time is relatively weak, the hybrids do not fill quickly, their coupling ability of early maturity is not strong. But in making such analysis, the actual situation of growth of the first generation hybrids in the field must be taken into consideration. For example, the coupling ability of the early heading time of Mexico 120 is relatively weak and its coupling ability of early maturity is relatively strong. The observed situation in the field showed its hybrids, like itself, withered early on a wide scale. This was not a normal maturation caused by the speed of filling.

Table 5   General Coupling Abilities of the Heading Times, Flowering Times
and Maturity Times of the 24 Parents of Rotational Breeding

Name of parent	Heading times (days)	Flowering times (days)	Maturity times (days)
Mexico 120	-0.3	-0.7	-1.4
Ai gan zao	-2.0	-0.4	-1.1
908	-0.4	0	-1.4
Anhui No 11	-0.1	-0.1	-0.6
Nan de zao shou No 1	-2.0	-0.6	-1.2
Ning 14526	-1.1	-0.4	-1.0
Yi wu bai ke zao	-0.6	-0.2	-1.9
Yunnan 525	-1.0	-0.5	-0.2
Early maturing jin zhou ai No 21	-0.3	-0.3	-0.2
Bo ta mu	0.1	0	1.0
E mai No 6	0.1	0	-0.1
Taiwan wheat	-0.5	0	-0.4
Pu shuang No 1	-1.1	-0.1	0.1
Hubei 975	0.3	0.1	0.6
$\mu.\rho.$ 301	1.4	0.2	0.4
Yang mai No 1	2.6	1.1	1.5
Ning 701	0.7	0.4	1.1
You yi wheat	1.1	0.4	1.4
Nong lin No 10	1.7	0.5	0.9
A zhong No 1	0.8	1.0	0.6
Feng chan No 3	0.9	0.7	0.9
Fan 6	0.1	-0.2	0.1
Jiu lan 39	0.8	0.4	0.4
Beijing No 8	-0.8	0	0.1

Early maturing Jin zhou ai No 21 was the variety that headed the earliest
in the field, but its coupling ability of early maturity was relatively
weak.   Its general coupling abilities of heading, flowering and maturity
times are -0.3, -0.3, -0.2 respectively.   The coupling ability of early
heading of Anhui No 11 is also relatively weak.   This indicates that an
early maturing variety may not be a good early maturing parent.   In breed-
ing of early maturing varieties, early maturing varieties whose early

maturity has a strong heritability and whose coupling ability is good must
be selected as the parent for hybridization.

The special coupling ability of heading time of the 275 first generation
hybrids was estimated. The results show that different special coupling
abilities exist between different hybrid combinations. There were 28
combinations which possessed special coupling ability of a relatively
strong early tendency, or 10.2 percent. Of these, the six combinations
Bo ta mu x Ning 701, Nan da zao shou No 1 x Pu shuang No 1, Bo ta mu x Pu
shuang No 1, Ai gan zao x Taiwan wheat, Fan 6 x Beijing No 8 and 908 x Hubei
975 possess the strongest early tendency. Their special coupling ability of
heading times are respectively: -2.0, -2.0, -1.9, -1.8, -1.8, -1.7. There
were 26 combinations that possessed a special coupling ability of a rela-
tively strong late tendency, or 9.4 percent. Of these, the four combinations
Bo ta mu x Beijing No 8, Bo ta mu x Jiu lan 39, 908 x Ning 14526 and Mexico
120 x Nong lin No 10 possess the strongest late tendency. Their special
coupling ability of heading times are respectively: 3.8, 2.8, 2.5, 2.0.
The factors that produce this special coupling ability need to be subjected
to further genetic analysis in second generation hybrids.

4. Heredity of Heading Time in the Second Generation Hybrids

In this experiment, records were made of the heading times of the single
plants of the second generation hybrids of three hybrid combinations and
the plants tagged. The results were then used to compile a distribution
table (Table 6) for the numbers of headings by the single plant of F_2, and
polygonal graphs were drawn from the distribution of the numbers of headings
(Figures 2, 3, 4).

Table 6. Table of distribution of the number of times of heading of single
plants of the F_2 generation of three hybrid combinations

1) 早熟荆州矮21号 × 908			2) 早熟荆州矮21号 × 扬麦1号			3) 早熟荆州矮21号 × 农林10号		
4) 组 距	组 5) 值	次 6) 数	组 距	组 值	次 数	组 距	组 值	次 数
12	12.5	2	15	15.5	5	17	17.5	2
14	14.5	4	17	17.5	10	19	19.5	5
16	16.5	4	19	19.5	16	21	21.5	61
18	18.5	30	21	21.5	41	23	23.5	246
20	20.5	203	23	23.5	136	25	25.5	216
22	22.5	349	25	25.5	235	27	27.5	76
24	24.5	100	27	27.5	92	29	29.5	7
			29	29.5	7			
7) 总 计		692			542			613

8) 注：组距以 3 月 31 日为 0 计算。

Key:
1. Early maturity Jin zhou ai No 21 x 908
2. Early maturing Jin zhou ai No 21 x Yang mai No 1
3. Early maturing Jin zhou ai No 21 x Nong lin No 10
4. Group distance
5. Group value
6. Number of times
7. Total
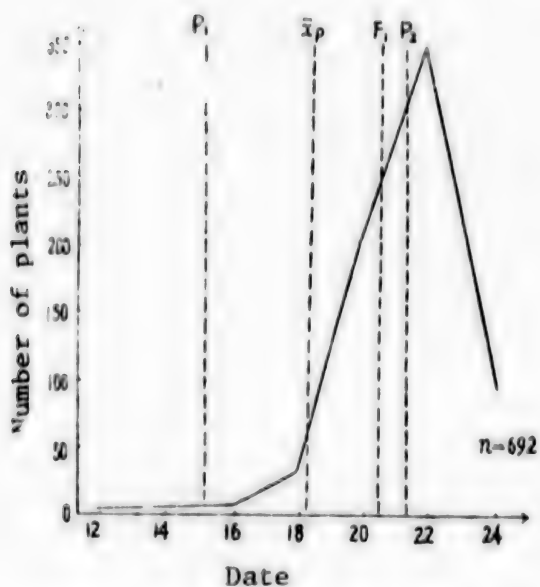8. Remark: Group distance begins on March 31 as 0.

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Figure 2   Distribution of the heading
times of single plants of F_2 of Jin
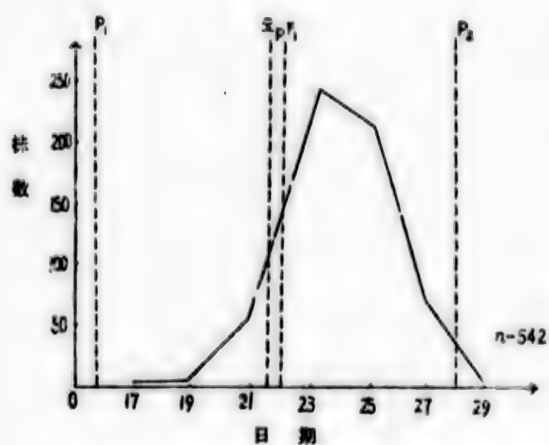zhou ai No 21 x 908

Figure 3   Distribution of heading
times of single plants of F_2 of Jin
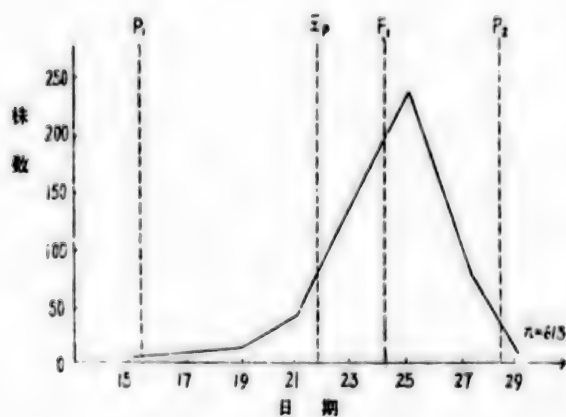zhou ai No 21 x Nong lin No 10

Figure 4   Distribution of the heading times of single plants of F_2 of Jin
zhou ai No 21 x Yang mai No 1

Table 7 Distribution of the Heading Times of Single Plants of the F₂
Generation of Three Hybrid Combinations

1) 合	2) 第一代 抽穗期类型	3) 总株数	4) 第二代抽穗期不同类型的百分率(%)					10)
			5) 偏早亲	6) 同早亲	7)早 偏中间型	8)晚 偏中间型	9) 同晚亲	偏晚亲
11)早熟晋州矮21×908	偏晚亲	692	0.9	0.3	4.6	29.3	25.3	39.6
12)早熟晋州矮21×扬麦1号	偏晚亲 14)	542	0.5	0.4	16.1	81.8	0.5	0.7
13)早熟晋州矮21×农林10号	偏晚亲	613	0	0	17.1	81.6	0.5	0.8

Key:
1. Combinations
2. Types of heading times of the first generation hybrids
3. Total number of plants
4. Percentages of the Different Types of Heading Times of the Second
    Generation Hybrids (%)
5. Earlier than the early heading parent
6. At the same time as the early heading parent
7. Early intermediate type
8. Late intermediate type
9. At the same time as the early heading parent
10. Later than the late heading parent
11. Early maturing Jin zhou ai No 21 x 908
12. Early maturing Jin zhou ai No 21 x Yang mai No 1
13. Early maturing Jin zhou ai No 21 x Nong lin No 10
14. Towards late parent

It can be seen from the table of distribution of the times of heading and
the polygonal graphs that distribution of the heading times of single plants
of the second generation hybrids of the three combinations are close to a
normal distribution and show continuous variation. Thus heredity of the
heading time is a quantitative heredity controlled by many genes, and the
genetic basis is relatively complex. Therefore, there are more phenotypes
in the later generations, and fluctuations are easily brought about by
effects of external conditions.

According to measurements obtained in this experiment, the coupling abili-
ties of early heading times of the two varieties early maturing Jin zhou ai
No 21 and Zhe 908, two of the four parents chosen and used here, are very
weak, -0.3 and -0.4 respectively. The coupling abilities of late heading
times of Yang mai No 1 and Nong lin No 10 are the strongest, 2.6 and 1.7
respectively. The heading times of the first generation hybrids of the
three combinations bred by these varieties are all later than the average
of both parents and are of the late heading parent type. This affects the
distribution of the heading times of single plants of the second generation
hybrids. It can be clearly seen from Figures 2, 3, 4 and Table 7 that the
heading times of the second generation hybrids of the three combinations
mentioned above actually show an off (late) normal distribution and the head-
ing times of most of the single plants belong to the late intermediate type.

Among plants of the combination early maturing Jin zhou ai No 21 x Zhe 908, still over half of all single plants head close to or later than the late heading parent Zhe 908. Very few single plants that had a heading time earlier than the early heading parent emerged. Among plants of the early maturing Jin zhou ai No 21 x Nong lin No 10 combination, there were no single plants whose heading time was earlier than the early maturing parent.

The above shows that the coupling ability of early maturity of the parents and of the early maturing phenotypes of the first generation hybrids can visibly affect the genetic distribution of the heading times of the second generation hybrids and their later generations.

Brief Summary and Discussion

(1) The results of rotational breeding of 24 wheat varieties show that the early maturity of the first generation hybrids of wheat whether it is of the heading time, flowering time or maturity time, is manifested by these different types: earlier than the early parent, at the same time as the early parent, early intermediate (earlier than the average of both parents), late intermediate (later than the average of both parents), at the same time as the late parent, and later than the late parent. The heading times and flowering times are mostly of the early types. The heading times of 175 of the 275 first generation hybrids showed an early heading time. They constituted 63 percent of the total number of combinations. The flowering time of 184 of the total showed an early tendency, or 67 percent. The maturity time of the first generation hybrids of about one-third of the combinations had an early maturing tendency, but most of the combinations showed late maturity. This is because the first generation hybrids possess superior growth. Withering is slowed, the filling period is prolonged. This can raise the thousand grain weight but correspondingly delays maturity.

In recent years, many units have conducted detailed observations of the manifestations of the heading times of first generation hybrids and the results have been fairly consistent. They all showed that the heading times of first generation hybrids can simultaneously manifest all the above types but the main type is early heading. This indicates that the heredity of early heading can be dominant, incompletely dominant or recessive depending on the different genetic bases of the parents. But its heredity is mainly dominant. In practice, the strength of heritability of early maturity of the parents reflects the various types of heredity described above. Those varieties which possess the genetic basis for inheriting dominant early maturity are believed to be parents with a strong heritability of early maturity. But the limiting action of external conditions upon these characteristics must not be neglected.

Besides the hereditary characteristics of the parents, different types of combinations also may affect the manifestation of the heading time of the first generation hybrids. In the type of combinations of parents with close heading times, superior plants (that head earlier or later than the parents)

frequently and easily emerge. As the difference between the heading times of the parents increases, the types in the first generation hybrids having superior heading times tend to diminish, and the vast majority of combinations emerge as an early intermediate type.

(2) A close relationship exists between early maturity of the parents and early maturity of their hybrids. The results of correlative analysis show that an extremely obvious positive relationship exists between the heading times, flowering times and maturity times of the parents and those of their hybrids. Their correlation coefficients are respectively: Heading times: $r = 0.86**$; flowering times: $r = 0.64**$; maturity times: $r = 0.73**$. This shows that early maturity of the hybrids is determined to a large extent by the early maturity of the parents. The key to breeding early maturing varieties and forming early maturing hybrid wheat combinations is the selection and use of ideal early maturing parents.

Three regressive equations were formulated for regressive analysis of the results. Heading time $Y = 15.28 + 0.31x$. Flowering time $Y = 21.13 + 0.19x$ Maturity time $Y = 33.72 + 0.33x$. The regressive equations above can be used to estimate the growth periods of hybrids from the growth periods of their parents.

(3) The coupling ability of early maturity of different parents shows obvious differences. Measurements obtained in this experiment shows parents with a relatively strong coupling ability of early heading time are Nan da zao shou No 1, Ai gan zao, Ning 14526, Pu shuang No 1 and Yunnan 525. Parents with a relatively strong coupling ability in early maturity are Yi wu bai ke zao, Zhe 908, Nan da zao shou No 1, Ai gan zao and Ning 14526. Since after heading, flowering may still be early or late and the speed of filling may be fast or slow, the coupling abilities of early heading and early maturity times are not entirely consistent. In choosing and using early maturing parents, these two aspects must be comprehensively taken into consideration.

The coupling abilities of early maturity times among early maturing varieties may be strong or weak. The coupling abilities of early maturity times of early maturing Jin zhou ai No 21 and Anhui No 11 are both weak. Therefore, an early maturing variety may not be a good early maturing parent. In practice, an early maturing variety with a strong coupling ability of early maturity time must be chosen and used as the early maturing parent. Besides those varieties measures in this experiment, some breeding units also believe regional varieties such as Jiang dong men and its derivatives, Tai he and IRN68-77 also possess relatively strong coupling ability of early maturity times.

The special coupling ability of heading times of the 275 hybrid combinations also show obvious differences. Some combinations possess relatively strong coupling abilities of early tendencies. Further exploration of the question concerning special coupling ability of early maturity of wheat has realistic meaning in the study of the hereditary patterns of early maturity and in the selective breeding of especially early maturing wheat varieties.

(4) The distribution of the heading times of single plants of the second generation hybrids shows a continuous variation. Thus heredity of the heading time of wheat is a quantitative characteristic, and is controlled by many genes, thus it is easily affected by environmental conditions.

Because the coupling abilities of early heading times of the parents of the three combinations tested were all very weak, the heading times of the second generation hybrids actually showed an off (late) normal distribution, while some units have obtained results of an off (early) normal distribution. This may be due to the differences in the coupling abilities of early tendencies of the parents of the combinations tested. This indicates that the coupling abilities of early heading times of the parents not only affects the manifestation of the heading times of the first generation hybrids but also affects the genetic distribution of the heading times of the second generation hybrids and necessarily affects to a certain degree the heading times of hybrid offspring generations.

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